MEDICAL TREATMENT
OF TOOTH ROOT CANAL SYSTEM

Minsk BSMU 2022

МИНИСТЕРСТВО ЗДРАВООХРАНЕНИЯ РЕСПУБЛИКИ БЕЛАРУСЬ
БЕЛОРУССКИЙ ГОСУДАРСТВЕННЫЙ МЕДИЦИНСКИЙ УНИВЕРСИТЕТ
КАФЕДРА ЭНДОДОНТИИ

МЕДИКАМЕНТОЗНАЯ ОБРАБОТКА СИСТЕМЫ КОРНЕВЫХ КАНАЛОВ ЗУБОВ

MEDICAL TREATMENT OF TOOTH ROOT CANAL SYSTEM

Учебно-методическое пособие

Минск БГМУ 2022

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М42

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М42 **Медикаментозная** обработка системы корневых каналов зубов = Medical treatment of tooth root canal system : учебно-методическое пособие / А. В. Бутвиловский [и др.]. – Минск : БГМУ, 2022. – 28 с.

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Рассмотрены основные вещества, используемые для медикаментозной обработки в эндодонтии. Представлены общие правила и протоколы медикаментозной обработки системы корневых каналов, охарактеризованы способы активации ирригантов для повышения их активности.

Предназначено для студентов 5-го курса медицинского факультета иностранных учащихся, обучающихся на английском языке по специальности «Стоматология» и клинических ординаторов.

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MOTIVATIONAL CHARACTERISTIC OF THE TOPIC

Topic of the class: Medical treatment of root canals. Agents for intracanal therapy.

Total class time: 7 academic hours.

Currently, diseases of the pulp and apical periodontium are the most common cause of tooth extraction. Endodontics is one of the most complex parts of therapeutic dentistry. Significant difficulties in endodontic treatment are created by the variety of nosological forms of diseases of the pulp and apical periodontium, a large number of approaches to mechanical and medical treatment of the endodont and post-endodontic tooth restoration techniques. Of particular note is the complexity and variability of the anatomy of the root canals of the teeth (curvatures, lateral canals, isthmuses, apical delta), which allows us to speak of them as a system. In the research of Peters O. A. et al. (2001) it was found that during mechanical preparation of the root canal system, 35 % or more of their surfaces remain untreated, which determines the need for thorough irrigation.

In recent years, a large number of publications devoted to endodontic treatment have appeared. This is due, among other things, to the proposal of new irrigants for medical treatment of root canals, the creation of new protocols for their use, and new ways to activate them. The above reasons determine the need to summarize and systematize a large amount of information about the medical treatment of root canals in this textbook.

Objective: to integrate knowledge about the principles and agents for medical treatment of the root canal system of the teeth.

Class tasks. The student must know:

1. Tasks and rules of medical treatment of the root canal system.
2. Agents for intracanal therapy and their characteristics.
3. Modern protocols for medical treatment of root canals.
4. Ways to activate irrigants in the root canal.

Requirements for the initial level of knowledge:

– from human morphology: anatomy of teeth;
– from general dentistry: the endodontic treatment of the root canal;
– from pharmacology: antiseptic and disinfectants.

Control questions from related disciplines:

1. Anatomy of teeth.
2. Method of extirpation, preparation and medical treatment of the root canal.
3. Antiseptic and disinfectants.

Control questions on the topic of the class:

1. Tasks and rules of medical treatment of the root canal system.
2. Agents used for medical treatment of the root canal system (sodium hypochlorite, EDTA, iodides, chlorhexidine, hydrogen peroxide, citric acid, etc.).

3. Modern protocols for medical treatment of the root canal system.
4. Ways to activate irrigants in the root canal.
5. Alternative ways to disinfect the root canal system.

TASKS AND RULES OF MEDICAL TREATMENT OF THE ROOT CANAL SYSTEM

The tasks of medical treatment of the root canal system are:

1. Maximum removal of microorganisms (disinfection).
2. Removal of residual pulp from the root canals.
3. Removal of the smear layer from the walls of the root canals.
4. Improving the efficiency and safety of mechanical preparation of root canals.
5. Creation of conditions for high-quality three-dimensional obturation.

General rules for medical treatment of the root canal system.

1. Endodontic treatment should be accompanied by isolation of the working field using a rubber dam or cotton rolls in combination with the “four-wall” technique, which makes it possible to exclude irrigants from entering the oral mucosa.

Currently, there are several options for the practical implementation of the “four walls” technique:

– preservation of the walls of the tooth;
– preservation of fragments of hermetic restorations as walls;
– making a temporary restoration with the subsequent creation of an endodontic access through it;
– use of copper (cupperband) or orthodontic rings;
– making a temporary crown with subsequent creation of endodontic access through it.

The choice of a specific option is determined by the degree of tooth decay, the presence of hermetic restorations and the planned service life of the temporary construction.

2. For irrigation, it is necessary to use endodontic syringes (with a soft piston stroke) and flexible needles with a rounded blunt top (closed-ended needles) and side holes (preferably double-sided), located at a distance of up to 3 mm from its top. The use of endodontic needles with an opening at the top (open-ended needles) is undesirable, since the risk of irrigant output into the periapical tissues is high. To securely connect the endodontic needle to the syringe, Luer Locks are used, which are equipped with most endodontic syringes.

3. Root canal irrigation should be carried out to a sufficient depth within the root canal system (a few millimeters before the apical foramen), which is controlled by placing a rubber stopper on the needle.

4. The needle should be freely positioned in the root canal (avoiding jamming!) to prevent its fragmentation and output of the irrigant into the periapical

tissues. The instillation of the solution should be accompanied by reciprocating movements.

5. The amount of irrigant per channel should be sufficient (large volumes of irrigants should be used — 10–15 ml), preferably the frequent instillation of new portions of the irrigant (they have a higher activity than partially inactivated old portions).

6. Before using each new substance, the previous one should be inactivated by irrigation with distilled water or saline (to prevent undesirable interaction of different substances with each other).

7. Removal of irrigants is preferably done with a narrow tip vacuum cleaner.

8. Medical treatment is carried out in 2 stages: the main one (during the mechanical preparation) and the final one (after the completion of the mechanical preparation). The last irrigant should not affect the properties of the materials used for root canal obturation.

AGENTS USED FOR MEDICAL TREATMENT OF THE ROOT CANAL SYSTEM

An ideal irrigant in endodontics should have the following properties:

1. Possess a wide spectrum of antimicrobial activity.
2. Have a lysing action to dissolve the remnants of the pulp and the organic matrix of the dentine.
3. Be able to completely remove the smear layer.
4. Do not irritate periodontal tissues.
5. Do not affect the physical properties of dentin.
6. Have low surface tension and lubricant properties.
7. Be stable in solution when stored.
8. Have low toxicity.
9. Be relatively inexpensive and accessible.
10. If possible, do not have an unpleasant smell and taste.

SODIUM HYPOCHLORITE

The "gold standard" for medical treatment of the root canal system is sodium hypochlorite (NaOCl) (Table).

In the mechanism of action of sodium hypochlorite, an important role plays an alkaline environment, the formation of hypochlorous acid (HOCl), chloramine, chlorine and oxygen:

– sodium hypochlorite breaks down lipids with the formation of glycerol and fatty acids, which leads to a decrease in the surface tension of the remaining solution;

– NaOCl neutralizes amino acids to form water and salt;
– the formation of hydroxyl ion provides an increase in pH level;
– hypochlorous acid and hypochlorite ions cause hydrolysis and degradation of amino acids;
– chlorine combines with amino groups of proteins to form chloramine.

Sodium hypochlorite (at a concentration of at least 1 %) has lysing properties, which makes it possible to dissolve the remains of the pulp and the organic matrix of predentin, and thereby facilitates the mechanical preparation of root canals. It is especially important that the content of the lateral canals and the apical delta, where mechanical processing is difficult, can be subjected to dissolution. It should be noted that the lysing effect of sodium hypochlorite is more pronounced in relation to necrotic tissues compared to vital ones. Pulp dissolution is known to occur within 20 minutes to 2 hours when using 5 % sodium hypochlorite. The lysing effect of sodium hypochlorite justifies its use as the primary irrigant during endodontic treatment.

Sodium hypochlorite has low surface tension and lubricant properties, which is important for more efficient and safe root canal preparation (facilitating the movement of the instrument in the canal and reducing the risk of its jamming). Moreover, it has a bactericidal effect on a wide range of gram-positive and gram-negative bacteria, and is active against fungi and viruses. Sodium hypochlorite oxidation of pigments formed during pulp necrosis or hemorrhage into it allows positioning its bleaching effect and effectively using it in the correction of tooth discolorations. Sodium hypochlorite also has a slight hemostatic effect.

The disadvantages of sodium hypochlorite as an irrigant in endodontics include its damaging effect when it enters the periapical tissues, unpleasant odor and taste, corrosion of metals (more often when used at a concentration of > 5 %, can lead to instrument fragmentation), the ability to discolor clothes and cause burns of skin and mucous membranes in contact with them. It should be recognized that the use of sodium hypochlorite does not allow to kill all bacteria (primarily Enterococcus and Candida) in the root canal system, completely remove the smear layer and slightly worsen the physical properties of dentin. This justifies the need for a combination of sodium hypochlorite with other agents for medical treatment of the root canal system.

Sodium hypochlorite is used in endodontics at a concentration of 0.5 % (Dakin's solution) to 6 %. With an increase in the concentration of sodium hypochlorite, its toxicity, lysing and antimicrobial action increases. It should be noted that 5 % sodium hypochlorite solution has a rather high toxicity, which limits its use. There are widespread recommendations for the use of sodium hypochlorite at a high concentration for medical treatment of the pulp chamber and the coronal third of the canals, at a concentration of 0.5 % for the treatment of the apical third of the canals, especially in the case of a wide apical foramen.

The most versatile 3 % concentration of sodium hypochlorite is used by most manufacturers. To reduce the damaging effect of sodium hypochlorite on tissues due to a strongly alkaline reaction (pH = 11–12), it is stabilized with a 0.5 % sodium bicarbonate solution, which makes it possible to reduce the pH of the solution without changing its antimicrobial properties. Also known is a method of stabilizing sodium hypochlorite with a 16 % sodium chloride solution ("Milton solution", "Procter & Gamble").

It has been established that the lower the concentration of sodium hypochlorite, the faster the solution is inactivated and the more often repeated instillation is necessary. The effectiveness of sodium hypochlorite depends on the temperature of the solution (the higher the temperature, the higher the efficiency), which justifies its preheating or activation (heating) by one of the known methods (Fig. 1).

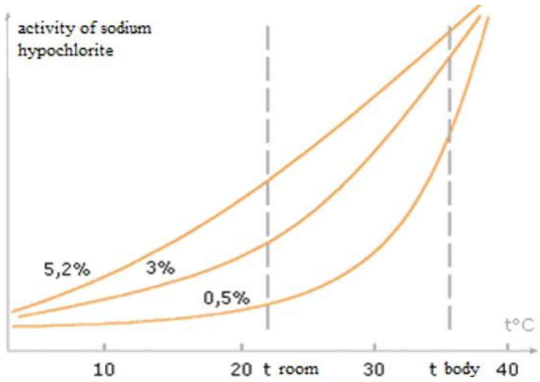


Fig. 1. Activity of sodium hypochlorite at different temperatures

When organics are lysed, the sodium hypochlorite solution becomes cloudy, so the preservation of its transparency can be used as a criterion for organics dissolution (completion of the main stage of medical treatment and the possibility of starting of the final irrigation).

When working with sodium hypochlorite, the following rules must be observed:

– comply with the storage conditions (do not store in the light, at high temperatures, contact with oxygen, avoid contact with metals);

– avoid output into the periapical tissues and contact with the skin and oral mucosa;

– mark the working length on the needle with a rubber stopper;

– prevent jamming of the needle in the root canal;

– let out the solution slowly with reciprocating movements of the needle;

– form a reservoir of solution in the coronal third of the canal, from where it will penetrate deeper when working with files;

– renew and activate the solution;

– it is forbidden to apply sodium hypochlorite immediately before or after irrigation with chlorhexidine solutions (their interaction leads to the formation of a hard-to-remove orange-brown precipitate — parachloraniline, which hampers obturation and is potentially carcinogenic).

To inactivate sodium hypochlorite in the root canal (before using another agent), the use of distilled water or saline is recommended.

At present, combinations of sodium hypochlorite of high concentration (5.25–5.85 %) with detergents (“Chlor-XTRA”, “Vista Apex”; “Hypoclean”, “OGNA”, “Chlor-axid extra”; “Cerkamed”) have been proposed, which should provide a decrease in surface tension, an increase wetting ability, increased lysing and oxidizing action.

When sodium hypochlorite goes outside the root canal, a complication called "hypochlorite accident" (NaOCl accident) is observed. The reasons for its occurrence are incorrect determination of the working length and violation of the irrigation technique (jamming of the needle in the root canal, the instillation with high pressure). In addition, the factors leading to this complication include failure to perform a diagnostic radiological examination, perforation of the walls of the root canal, a wide apical foramen (due to resorption or excessive preparation), anatomical features (for example, the absence of the upper cortical plate of the mandibular canal; more often in the area of the distal roots of the first permanent molars). The most dangerous is the excretion of sodium hypochlorite into the mandibular canal and maxillary sinus.

The chemical characteristics responsible for complete hydrolysis of biofilm produces devastating effects on living tissue. In classical study, Pashley et al (1985) investigated the effect on blood cells (RBC) and found that 5.25 % of NaOCl, when diluted with saline ratio of 1 : 1.000, produced 96.3 % hemolysis of an RBC sample. The study also included the intradermal injection effect using a rat model and 5.25 % of NaOCl. The intradermal injections resulted in immediate hemorrhage within the entire area of solution contact, and the affected areas ulcerated after 24 hours. Pashley at al. noted that serious clinical consequences of using NaOCl can be because of the passage of the solution through the root foramina (Fig. 2–4).

Fig. 2 demonstrates radiopaque dye extended into periapical tissues in teeth with necrotic pulps. Due to tissue reaction, post-op pain is likely a consequence.

The pathognomonic facial appearance of a NaOCl extrusion incident typically includes hemifacial edema and ecchymosis involving, one or both eyelids, and upper and lower lips, beginning at the angle of the mouse, but never includes the cheek area.

Fig. 3, *a* indicates the classical pathognomonic facial appearance of a NaOCl infusion resulting from the treatment of maxillary right lateral incisor. Although the right superior palpebral vein (red arrow) shows the hemorrhagic effect of NaOCl infusion, the midface area just below the eyelids is virtually unaffected. Fig. 3, *b*. The course of anterior facial vein and its tributaries including the palpebral veins of the eyelids, the superior and inferior labia veins, and, most importantly — an uncommon connection with superior alveolar veins, that normally drains blood from the teeth to the pterygoid plexus of veins in the infratemporal fossa. Fig. 3, *c*. The area between the eyelids and the angle of the mouth is unaffected because the malar fat pad and zygomatic muscles cover the anterior facial vein, thus hiding any hemorrhagic effect.

The posterior maxillary wall is critical anatomical feature because it forms a significant portion of the anterior boarder protecting the infratemporal fossa (Fig. 4). In addition to the pterygoid venous plexus, the infratemporal fossa contains the following nerves: mandibular (inferior alveolar, lingual, buccal), plus the otic ganglion and chorda tympani (yellow arrows). A few of the many abundant sinusoid spaces are identified throughout the maxilla.

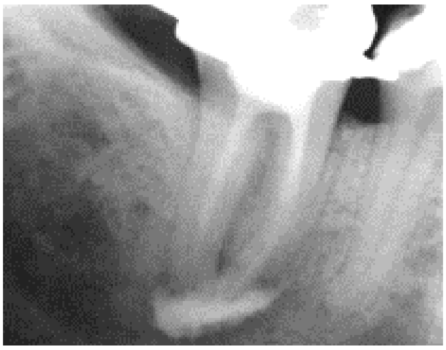
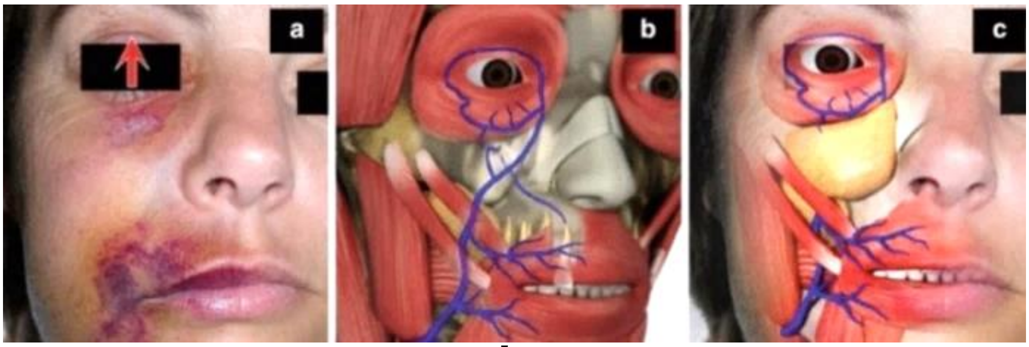


Fig. 2. Radiopaque dye extended into periapical tissues in teeth with necrotic pulps



a ***b*** ***c***

Fig. 3. Classical pathognomonic facial appearance of a NaOCl infusion resulting from the treatment of maxillary right lateral incisor

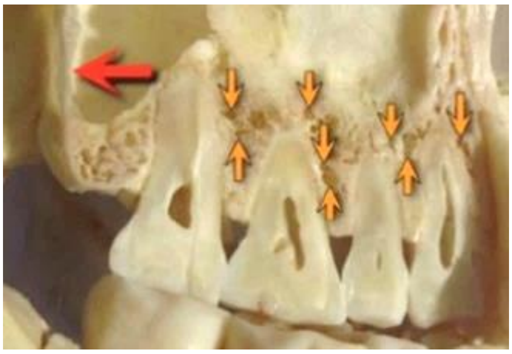


Fig. 4. Anatomy of posterior maxilla wall in context of protecting of infratemporal fossa

The clinic of the "hypochlorite accident": severe acute pain after irrigation with sodium hypochlorite, burning, profuse bleeding from the root canal, rapid development of soft tissue edema, ecchymosis and hematoma on the skin, trismus, paresthesia, hyperesthesia, and later — the addition of a secondary infection.

Post-extrusion treatment is directed toward preventing further deterioration. Each incident must be evaluated on individual basis because a multitude of factors must be considered including: severity of the incident, allergies to medication, side effects, dosing. Accordingly, the following general recommendations are summarized:

1. Inform the patient regarding the nature of the incident including the possible risk and complications.
2. Hospitalization is required in all cases of respiratory embarrassment or uncontrolled hemorrhage or when the need for intravenous medication is indicated.
3. Pain control can range from local anesthesia to analgesics.
4. Refer to an otolaryngologist when the maxillary sinus is involved or a nephrologist if the urine appears unusually dark.
5. Use external cold compresses for one day to reduce swelling.
6. After the first day, warm mouth rinses will stimulate blood flow.
7. Daily recall is required to monitor recovery.
8. Antibiotics are not always required but reserved in cases of high risk or evidence of secondary infection.
9. Corticosteroids are often given, but their use is controversial.
10. Further treatment like surgical intervention, tooth extraction, or sinus procedures must be assessed.

In light of the cytotoxicity of sodium hypochlorite, its extrusion from the root canal will affect periapical tissue and may cause the patient a series of complication. This does not imply that NaOCl can or should be excluded as an endodontic irrigant. In fact, its use is essential to achieve adequate chemical debridement. **What this does imply is that it must be delivered safety.**

Apical negative pressure devices have been shown to enable irritants to safety reach the apical one third in voluminous amounts and help overcome apical vapor lock (air entrapment at apical one third) as well as remove tissue and bacteria throughout the root canal system.

ETHYLENEDIAMINETETRAACETATE

EDTA (ethylenediaminetetraacetate) provides softening of the dentin of the root canal walls at a depth of 20–50 microns by chelating calcium ions and thereby facilitates mechanical preparation. In addition, the use of EDTA allows to effectively remove the smear layer, open the dentinal tubules and thus create conditions for the penetration of endodontic sealer into them.

The smear layer is an amorphous adhesive substance formed during the preparation of the root canal and consisting of microorganisms, pulp remnants, processes of odontoblasts and inorganic dentin matrix. The thickness of the smear layer is usually 1–2 μm, but when penetrating into the dentinal tubules, it can reach 40 μm. The need to remove the smear layer is due to the fact that it is a substrate for microorganisms and at the same time it protects them from the action of antiseptics. The activity of EDTA increases with increasing concentration and time of application. Currently, EDTA exposure for 1 minute in the amount of 5–10 ml per 1 channel is recommended, which ensures complete and safe removal of the smear layer (Johnson W. T. et al., 2009). With prolonged contact of EDTA with dentin (especially with the introduction of its fresh portions), the risk of damage to it increases significantly.

EDTA has an affinity for iron ions, which leads to the destruction of the biofilm due to the formation of chelate bonds. Also, EDTA can detach biofilms attached to the walls of root canals, which can be easily removed with subsequent irrigation. As all possible bonds with calcium and iron are formed, the chelating activity of EDTA stops, which is called a “self-limiting action”.

The disadvantage of EDTA is the ability to negatively affect the binding of the photosensitizer to the membranes of microorganisms and form precipitates when interacting with chlorhexidine, which reduces the ability to remove the smear layer. There is evidence (Grawehr M. et al., 2003) that the interaction of EDTA with sodium hypochlorite results in a significant decrease in its lysing and antimicrobial activity.

EDTA is available as a neutral pH buffered solution or gel, preferably at a concentration of 17 %. At this concentration, an exposure of about 1 minute is required to realize the action of EDTA. The use of liquid EDTA is recommended when blocking the root canal with dentine plugs.

Manufacturers often combine EDTA with other active ingredients:

– quaternary ammonium compounds with surface-active and antiseptic properties (cetrimide — “Largal Ultra”, “Septodont”; benzalkonium chloride — “Endoseptin-17”, “Belaseptika”; centimonium bromide — “Endogy № 2”, “VladMiVa”);

– hydrogen peroxide (antiseptic, oxidizing agent) — “Canal+” (“Septodont"), “SurePrep” (“Spident”);

– carbamide peroxide (antiseptic, oxidizing agent) — “Glyde” (“Dentsply Caulk”).

Thus, sodium hypochlorite and EDTA are the main agents in the medical treatment of the root canal system, since their combined use allows us to lyse organic debris, remove the smear layer and kill most of the microorganisms.

During the final irrigation after EDTA inactivation, it is recommended to neutralize it with sodium hypochlorite to stop the demineralizing effect.

CHLORHEXIDINE

Chlorhexidine is a cationic detergent with a prolonged bacteriostatic and bactericidal effect (depending on concentration) on gram-positive and gram-negative microbes, active against fungi and viruses. The most stable form of this antiseptic is gluconate. The antimicrobial effect of chlorhexidine is most pronounced at pH = 5.5–7.0 and decreases in the presence of organic substances. At low concentrations, chlorhexidine disrupts the osmotic balance of bacteria; at high concentrations, it causes precipitation and coagulation of their cytoplasmic proteins. The bactericidal effect of chlorhexidine solution is especially pronounced with respect to gram-positive flora.

Chlorhexidine is an additional irrigant in the medical treatment of the root canal system, since it does not have a lytic effect and the ability to remove the smear layer. The expediency of its use in endodontics is associated with a wide antimicrobial spectrum of action and low toxicity (compared to sodium hypochlorite). In addition, it is able to adhere to dentin hydroxyapatites and not be inactivated during canal treatment.

The disadvantage of chlorhexidine is that it is more effective against gram-positive than gram-negative microorganisms. In terms of antimicrobial activity against E. faecalis, chlorhexidine is inferior to iodinol.

In endodontics, chlorhexidine is more often used at a concentration of 2 % (bactericidal action).

To improve antimicrobial properties, a combination of chlorhexidine bigluconate with detergents (“CHX-Plus”, “Vista Apex”) was proposed, the effectiveness of which is currently the subject of scientific research.

IODIDES

Iodides are used in the medical treatment of root canals as an additional antimicrobial agent that kills bacteria, fungi and viruses. In endodontics, 5 % iodinol (potassium iodide iodine solution), Churchill solution (16.5 g iodine, 3.5 g potassium iodide, 20 g distilled water and 60 g 90 % ethanol), 2 % iodine solution, 4 % potassium iodide solution and 10 % povidone-iodine solution (0.9–1.2 g of active iodine in 100 ml).

Iodides are characterized by low toxicity and high efficiency against E. faecalis (in comparison with sodium hypochlorite), which justifies the expediency of a combination of these agents.

It is known that a 10 % solution of povidone-iodine has 100 % activity against all strains of E. faecalis organized into a biofilm, with an exposure of 2 minutes.

To realize the antimicrobial action of iodide solutions, it is necessary first to remove the smear layer with sodium hypochlorite and chelating agents, that is, they should be used during the final irrigation of the root canal system.

Before using iodides, a thorough anamnesis taking is necessary to identify possible contraindications (hypersensitivity to iodine, thyroid diseases (hyperthyroidism, adenoma), Dühring's herpetiform dermatitis, etc.). The disadvantage of using iodides is the possible staining of the hard tissues of the tooth (especially when using high concentrations).

Hydrogen peroxide

Hydrogen peroxide (H_2O_2) remains an additional antibacterial agent in endodontics and is used at a concentration of 3–5 %. The effectiveness of hydrogen peroxide depends on the concentration, with increasing toxicity for high concentrated solutions.

The mechanism of action is based on the formation of active oxygen, which causes the death of bacteria, fungi and viruses. Due to the release of oxygen, the activity is more pronounced relative to the anaerobic microflora. However, compared to sodium hypochlorite, the antimicrobial effect of hydrogen peroxide is negligible. The interaction of these substances leads to a decrease in their activity due to a chemical reaction between them, accompanied by the release of oxygen.

The appearance of oxygen bubbles causes the effect of foaming, which contributes to the mechanical cleaning of the root canal from the remnants of the pulp and microorganisms. However, when the bubbles move apically, an airlock is formed and this effect can cause severe pain. The disadvantages of hydrogen peroxide also include its instability when heated and exposed to light.

Citric acid

Citric acid, as well as EDTA, can act as a chelating agent in endodontic treatment. In the medical treatment of root canals, citric acid is used at a concentration of 1 to 50 %. Currently, the use of 10 % citric acid is recommended because citric acid at this concentration is more effective than EDTA in smear layer removal, dentine softening, and antimicrobial properties. The advantages of citric acid compared to EDTA are higher efficiency in removing calcium hydroxide from the root canal and the possibility of usage in photodisinfection.

The interaction of citric acid and sodium hypochlorite should be avoided (the antimicrobial and lytic effect of NaOCl is reduced) by separating these solutions with distilled water or saline.

New irrigants

New irrigants for medical treatment of root canals that have recently appeared on the market include “MTAD” (“BioPure”), “Q-Mix” (“Dentsply”), “Tetraclean” (“Ogna”) and “Dentiseptin” (“Belaseptica”).

"MTAD" (mixture of tetracycline, acid and detergent), proposed in 2003 by Tarabinejad M. et al., is a combination of 3 % doxycycline, 4.25 % citric acid and detergent (0.5 % polysorbate 80). According to developer research, it effectively removes the smear layer, acts on E. faecalis, and does not affect the physical properties of dentin. Irrigation with "MTAD" is recommended in combination with sodium hypochlorite, at the final stage of medical treatment for 5 minutes. The scientific literature discusses the feasibility of using "MTAD" in the context of high resistance of microorganisms to tetracyclines, a lower bactericidal effect on E. faecalis in biofilm compared to 1–6 % sodium hypochlorite, a negative effect on subsequent obturation with gutta-percha points with epoxy resin.

"Q-Mix" contains chlorhexidine, EDTA and detergent. "Q-Mix" has good smear removal properties (same as 17 % EDTA) and higher antimicrobial activity compared to 1–2 % sodium hypochlorite and 2 % chlorhexidine. It is recommended for final root canal irrigation for 1–1.5 minutes.

"Tetraclean" is proposed as a mixture of doxycycline (50 mg/ml; lower concentration compared to MTAD), citric acid, detergent (polypropylene glycol) with low surface tension. There is evidence of a greater antimicrobial activity of "Tetraclean" compared to "MTAD". Its use is also recommended at the final stage of medical treatment of the root canal system.

"Dentiseptin" contains sodium hypochlorite (at a concentration of 3 % or 5.25 %), sodium hydroxide and tetrasodium EDTA. The combination of NaOCl and EDTA reduces the time spent on medical treatment of root canals.

Basic agents for medical treatment of the root canal system

Active ingredient, concentration	Medications	Action
Sodium hypochlorite 0.5–5.25 %	"Milton" (3 %, "Procter & Gamble"), "Parkan" (3 %, "Septodont"), "Belodez" (3 %, 5.2 %, "VladMiVa"), "Hypochloran" (3 %, 5 %, "Omega Dent"), "Sodium hypochlorite" (3 %, "TechnoDent") "Dentiseptin" (3 %, 5.25 %, "Belaseptika")	Antimicrobial, lysing, friction reduction, bleaching, hemostatic
EDTA 15–19 %	"EDTA solution" (17 %, "Pulpdent"), "Largal Ultra" (15 %, "Septodont"), "Endozhi No. 2" (15 %, "VladMiVa"), "Glyde" (15 %, "Dentsply Caulk"), "Canal+" (10–25 %, "Septodont"), "SurePrep" (15 %, "Spident") "Endoseptin" (17 %, "Belaseptika")	Removal of the smear layer, softening of the dentine, antimicrobial
Iodides	"Iodinol" ("BZMP") Churchill solution "Povidone-iodine" (10 %, "EGIS")	Antimicrobial

The end of the table

Active ingredient, concentration	Medications	Action
Chlorhexidine 0.05–2 %	“Chlorhexidine bigluconate” (0.05 %, “Belmedpreparaty”), “Antiseptic liquid based on chlorhexidine bigluconate” (2 %, “TechnoDent”) “Consepsis” (2 %, “Ultradent”)	Antimicrobial
Hydrogen peroxide 3–5 %	“Hydrogen peroxide” (3 %, “Belmedpreparaty”)	Antimicrobial, cleansing, hemostatic
Citric acid, 1–50 %	“Citric acid” (40 %, “Cercamed”) “Citric acid” (20 %, “Ultradent”)	Smear layer removal, softening of the dentine, antimicrobial

MODERN PROTOCOLS FOR MEDICAL TREATMENT OF THE ROOT CANAL SYSTEM

The general algorithm of medical treatment is shown in Fig. 5.

In the Republic of Belarus, there is an instruction for the use of “Methods of antiseptic treatment of root canals in the treatment of pulpitis and apical periodontitis” No. 054–0518, approved by the Ministry of Healthcare in 2018 (hereinafter referred to as the instruction).

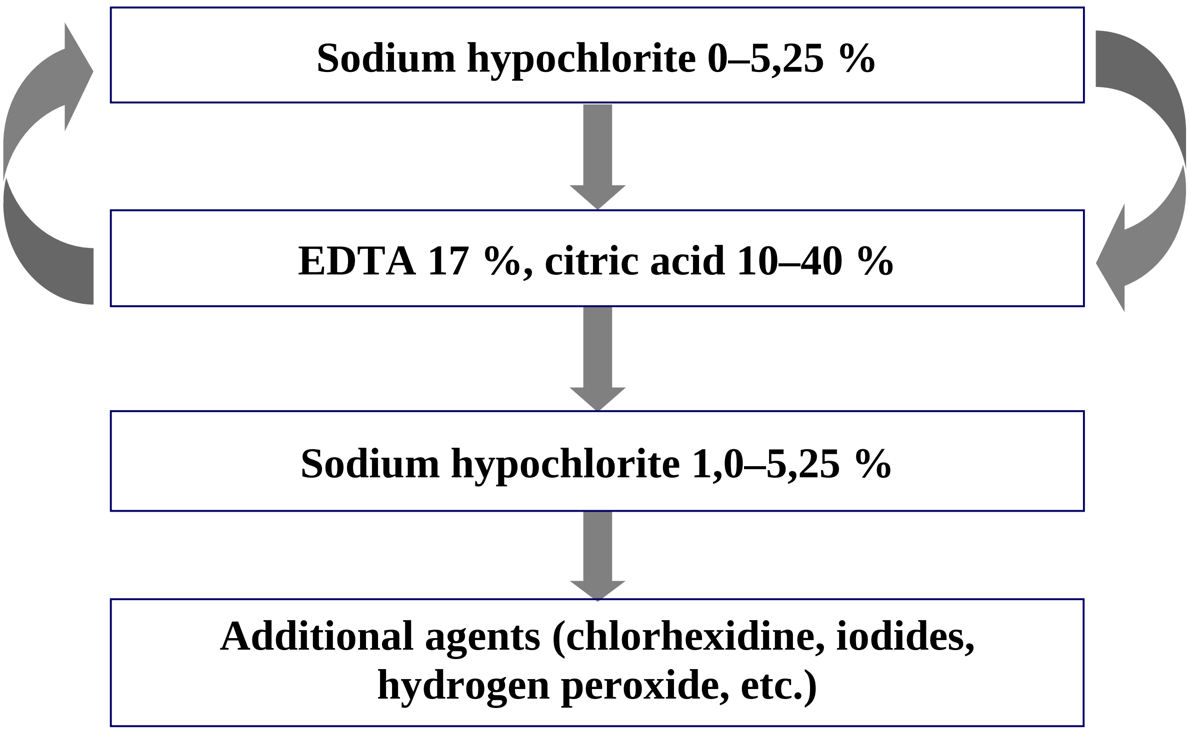


Fig. 5. General algorithm for medical treatment of the root canal system

According to the instruction, for pulpitis after creating an endodontic access, it is necessary:

– treat the pulp chamber with 5.25 % sodium hypochlorite;

– during mechanical preparation of the root canal, after each instrument, instill with 5.25 % sodium hypochlorite (exposure time 1–5 minutes, amount of agent — 2–5 ml);

– inactivate NaOCl by washing with distilled water in an amount of 5–10 ml;

– perform a final irrigation, including exposure of 17 % EDTA solution (3–5 minutes; 8–10 ml; with sonic activation for a minute), rinsing with distilled water (5–10 ml), exposure of 5.25 % sodium hypochlorite solution (5 minutes; 10–20 ml; with activation for a minute), washing with distilled water (5–10 ml).

For apical periodontitis, the medical treatment protocol is distinguished by the use of 3 % (rather than 5.25 %) sodium hypochlorite and the addition of an exposure of 2 % chlorhexidine bigluconate solution (3–6 minutes; 4–10 ml) at the end of the final irrigation.

WAYS TO INCREASE THE ACTIVITY OF IRRIGANTS IN THE ROOT CANAL

Medical treatment of the root canal system requires significant time compared to their preparation. At the same time, there are difficulties in penetration of the irrigant into the apical third of the root canal.

The main ways to increase the activity of irrigants include:

– frequent replacement of solutions;
– using more amount of irrigants;
– heating (in relation to sodium hypochlorite);
– usage of detergents;
– activation;
– greater preparation of the root canal and giving it a conical shape.

In the process of realizing the action of the irrigant, it is inactivated, therefore, the frequent introduction of new portions of it and the use of large volumes can increase the effectiveness of medical treatment. When sodium hypochlorite is heated, its activity increases, so some clinicians recommend preheating it to body temperature (especially when working with low concentrations of NaOCl). Detergents, as substances with high surface activity, ensure rapid distribution of substances over the surface and thus increase the effectiveness of their action.

The activation of the irrigant (primarily sodium hypochlorite) can be carried out mechanically, using ultrasound, sound, and special instruments (“XP-EndoFinisher”, “FKG”).

Mechanical activation of the irrigant (mixing) is traditionally recommended using files, gutta-percha points and special brushes (also available in the rotary version: for example, “Versa-Brush”, “VistaApex” (Fig. 6)). It should be noted that brushes are more often recommended for activating EDTA solutions.

Fig. 6. Brushes for mechanical activation of the irrigant “Versa-Brush” (“VistaApex”)

Ultrasonic vibrations of the activation tips (20–40 kHz) provide the effects of cavitation (the appearance and collapse of bubbles), microstreaming (stable unidirectional circulation of liquid near a small vibrating object) and heat generation (heating of the solution), which contributes to better penetration of the irrigant into hard-to-reach areas of the root canal system.

For ultrasonic activation, special tips are used (for example, E4, E4D “NSK”; ED14D, ED15D “WoodPecker”; nickel-titanium “Pro Ultra”, “Dentsply”) or systems consisting of files and their holder — endochuck (Fig. 7).

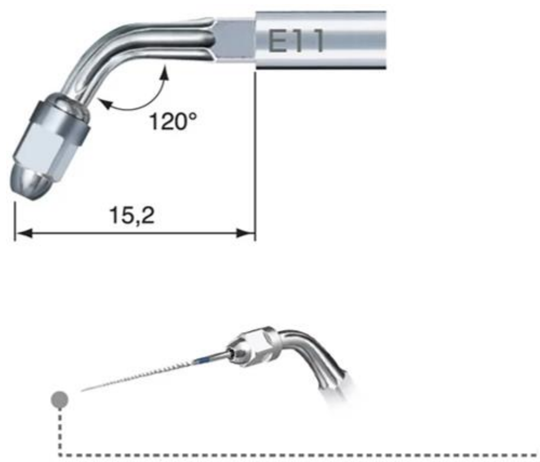


Fig. 7. Endochuck E11 (“NSK”) and U-file №30 inserted into it

Endochuck for anterior teeth, as a rule, has an angle of 120 degrees (E11 “NSK”; ED1 “WoodPecker”), and for chewing teeth — 95 degrees (E12 “NSK”; ED2 “WoodPecker”). Ultrasonic activation files can be steel or nickel-titanium (more flexible), more often have a 2 degree taper and come in sizes from 15 to 40 (NSK U-files, WoodPecker NiTi K-files).

Ultrasonic activation in endodontics should be passive (the file should not be in contact with the root canal walls) in order to penetrate the irrigant to the maximum depth, prevent the formation of ledges and stripping of the canal walls.

It has now been proven that the use of ultrasonic activation can reduce the number of microorganisms in the root canal. Ultrasonic activation is not feasible along the entire length of strongly curved root canals; it can only be carried out in their relatively straight part.

In case of significant bending of the root canals, it is recommended to use sonic activation (Fig. 8) and / or the "XP-EndoFinisher". For sonic activation, the device "EndoActivator" ("Dentsply") is proposed with 3 speeds of operation (2000, 6000 and 10000 cycles per minute) and flexible polymer tips: small 15/02 (yellow), medium 25/04 (red) and large 35/04 (blue). The choice of the tip is determined by the degree of preparation of the root canal according to the principle: the tip must be immersed at a distance of at least 2 mm from the apical foramen. The use of sonic activation is not accompanied by the risk of changing the anatomical shape of the root canal.

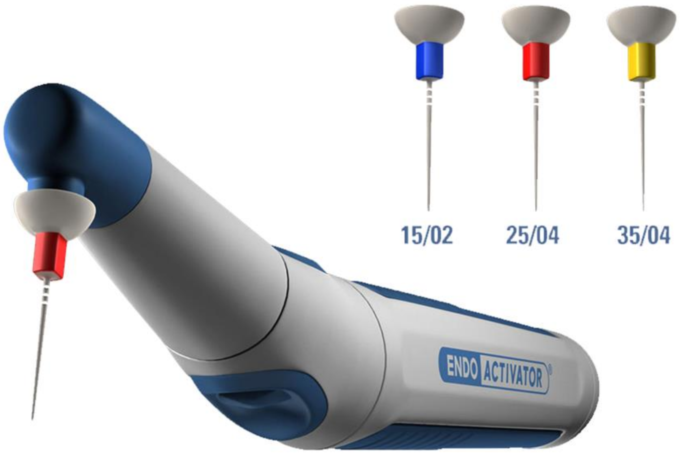


Fig. 8. Device for sonic activation "EndoActivator" ("Dentsply") and its tips

Sonic activation is less effective than ultrasonic activation.

The "XP-EndoFinisher" ("FKG") file is made of a MaxWire alloy that exists in two phases — martensitic (when cooled; file becomes straight) and austenitic (when heated; with bending of the tool tip). It has a zero taper and size 25 (which ensures resistance to cyclic loads), therefore it is recommended for use in canals expanded to at least size 25 (Fig. 9).

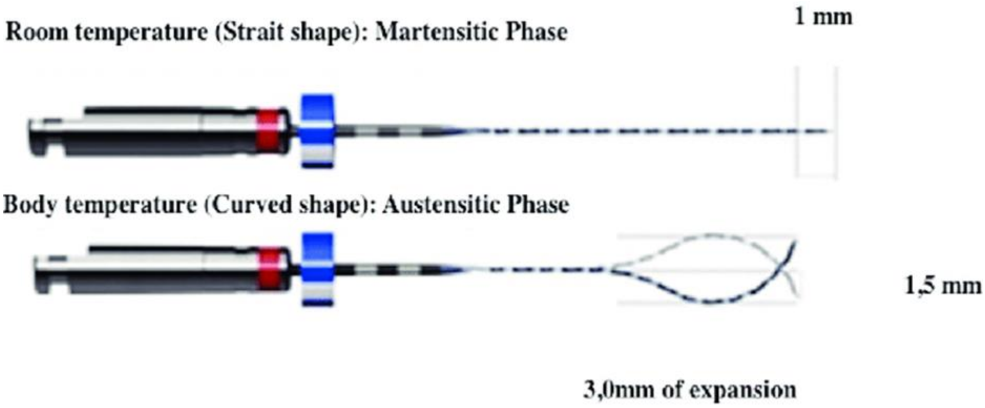


Fig. 9. View of the file "XP-EndoFinisher" ("FKG") in the martensitic and austenitic phases

When rotating in the root canal (torque 1N/cm and rotation speed 800–1000 rot/min), this file takes the form of a spindle (with a size of up to 6 mm), adapts to the shape of the canal and contacts with all its walls. The stages of work with “XP-EndoFinisher” are:

1. Fixing the working length with a stopper using a special ruler.
2. Filling the root canal with an irrigant.
3. Cooling of the tool for the transition to the martensitic phase, which is accompanied by its straightening.
4. Insertion of the instrument into the canal with its subsequent heating and shape change.
5. Work with reciprocating movements with an amplitude of 7–8 mm for 1 minute.

The advantage of activation using the “XP-EndoFinisher” is that during operation it penetrates into the anastomoses and lateral canals (including the apical delta), providing their chemical-mechanical preparation without the risk of changing the anatomical shape.

To increase the depth of penetration of irrigants, the degree of expansion of the root canal, its shape, activation of irrigants, as well as the choice of endodontic needles are of great importance.

Endodontic needles have a size of 23G (on the Gauge scale), which corresponds to an outer diameter of the tip of 0.6 mm; 27G — 0.4 mm; 30G — 0.3 mm; 31G — 0.25 mm.

The most appropriate and versatile is the use of thin needles with side openings of size 30G (“Endonidl”, “Omegadent”; “VistaProbe”, “VistaApex”) and 31G (“NaviTip Sideport”, “Ultradent”). The "gold standard" for curved root canal are “NiTi Superflex” needles (“VistaApex”), which have increased flexibility (Fig. 10).

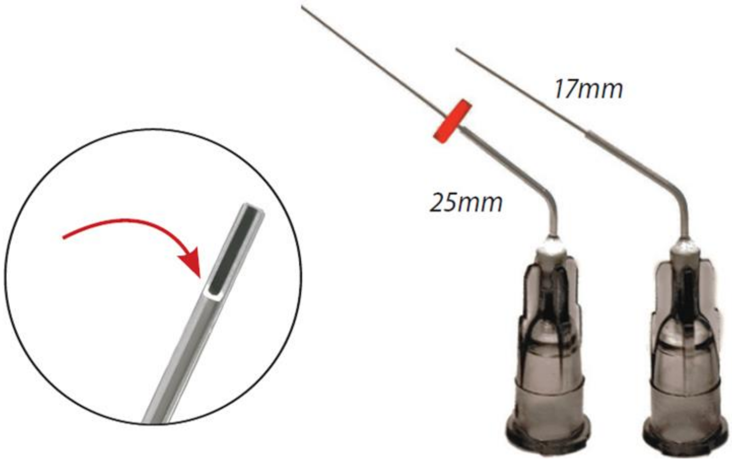


Fig. 10. Nickel-titanium needles “NiTi Superflex” (“VistaApex”)

ALTERNATIVE WAYS
TO DISINFECT THE ROOT CANAL SYSTEM

Alternative methods of root canal disinfection include photodisinfection, ozone disinfection, laser application, and electrochemical water activation.

The principle of photodisinfection is the introduction of a photosensitizer into the root canal, which binds to the membranes of microorganisms. After activation of the photosensitizer by a laser of a certain wavelength, a photocytoxic effect is observed (the photosensitizer catalyzes the formation of reactive oxygen species that destroy bacterial cells). Tolonium chloride, methylene blue, riboflavin and other substances have been proposed as photosensitizers in endodontics.

An example of a photodisinfection apparatus is "EndoEst Assistant" ("GeoSoft"). The technique of carrying out consists in introducing a photosensitizer into the root canal, maintaining the exposure and irradiating the canal (at a length of at least 4 mm from the apical opening) for 30–150 seconds.

Disinfection with ozone is carried out by introducing pre-ozonized and cooled (to increase the activity time) physiological solution or water into the root canals. This method of medical treatment remains poorly studied and therefore is not recommended for use in clinical practice.

Electrochemical activation of water involves the electrolysis of an aqueous electrolyte solution, which leads to the formation of two solutions — anolyte (solution at the anode), which has a low pH value and strong oxidizing properties, and catholyte (solution at the cathode), which has a high pH value and reductant properties. An example of an apparatus for this is "Sterilox" with a solution, the electrolysis of which produces sodium hydroxide (pH = 12.5; catholyte) and 85–95 % hypochlorous acid (anolyte; Sterilox solution). There is evidence that these solutions are inferior in efficiency even to 0.5 % sodium hypochlorite solution.

Lasers used for disinfection in endodontics are used in dried or antiseptic filled root canals. At the same time, microorganisms and pulp residues are well removed, the dentin surface becomes smooth, and the lateral tubules are sealed. The use of a laser during endodontic treatment is contraindicated in a large number of diseases and conditions (decompensation of diabetes mellitus and diseases of the cardiovascular system, oncological diseases, tuberculosis, leukoplakia, condition less than 6 months after myocardial infarction, etc.). The disadvantages of using a laser are associated with the direction of the beam along the axis of the canal, which does not allow for a full impact on its walls and is accompanied by the risk of damage to the periapical tissues. In addition, the disadvantages of the laser can be attributed to its high cost and complexity of application in narrow root canals.

SELF-CONTROL OF TOPIC COMPREHENSION

1. Agents used to remove the smear layer from the walls of the root canal:

a) 3 % hydrogen peroxide;
b) iodinol;
c) EDTA;
d) 0.05 % chlorhexidine bigluconate;
e) iodides.

2. The primary agent for irrigation in endodontics is:

a) sodium hypochlorite;
b) phosphoric acid;
c) alcohol;
d) ether;
e) iodides.

3. To remove the smear layer from the walls of the root canal, EDTA is used at a concentration of:

a) 3 %;
b) 17 %;
c) 2 %;
d) 40 %;
e) 0.05 %.

4. Chelating agents used in endodontics:

a) sodium hypochlorite;
b) citric acid;
c) EDTA;
d) ether;
e) iodides.

5. Concentration of chlorhexidine bigluconate most commonly used in endodontic treatment is:

a) 3 %;
b) 17 %;
c) 2 %;
d) 40 %;
e) 0.05 %.

6. The concentration of sodium hypochlorite most commonly used in endodontic treatment is:

a) 3 %;
b) 17 %;
c) 0.2 %;
d) 40 %;
e) 0.05 %.

7. Possible ways to activate sodium hypochlorite solution in curved root canals are:

a) XP EndoFinisher;
b) ultrasound;
c) Endo activator;
d) H-files;
e) Thermaprep.

8. The main agents used for medical treatment in endodontics are:

a) sodium hypochlorite and distilled water;
b) phosphoric acid and sodium hypochlorite;
c) alcohol and EDTA;
d) EDTA and sodium hypochlorite;
e) iodides and sodium hypochlorite.

9. The solution recommended for use after washing the root canal with EDTA and its neutralization:

a) sodium hypochlorite;
b) citric acid;
c) iodinol;
d) ether;
e) iodides.

10. The last solution recommended for washing the root canal before permanent obturation:

a) sodium hypochlorite;
b) citric acid;
c) saline or distilled water;
d) ether;
e) iodides.

11. Additional antimicrobial agents that can be used in endodontic treatment:

a) sodium hypochlorite;
b) chlorhexidine bigluconate;
c) Churchill's solution;
d) ether;
e) iodides.

12. Possible ways to activate the sodium hypochlorite solution in the straight part of the root canals are:

a) XP EndoFinisher;
b) ultrasound;
c) Endo activator;
d) Sterilox;
e) Thermaprep.

13. Needles used for irrigation in endodontic treatment should preferably:

a) have a blunt top;
b) be rigid;
c) be flexible;
d) have top openings;
e) have side openings.

14. Possible ways to increase the activity of sodium hypochlorite solution during endodontic treatment are:

a) cooling the solution;
b) heating the solution;
c) usage of Endo Activator;
d) usage of more concentrated solutions;
e) combine it with chlorhexidine.

15. During endodontic treatment, it is forbidden to use the following substances in sequence:

a) sodium hypochlorite and saline;
b) chlorhexidine and sodium hypochlorite;
c) distilled water and EDTA;
d) EDTA and saline;
e) saline and iodides.

16. As the main active substance "Endoseptin" contains:

a) sodium hypochlorite;
b) chlorhexidine bigluconate;
c) EDTA;
d) ether;
e) iodides.

17. Inactivation of sodium hypochlorite in the root canal should be carried out using:

a) saline;
b) chlorhexidine bigluconate;
c) distilled water;
d) EDTA;
e) iodides.

18. As the main active substances "Dentiseptin" contains:

a) sodium hypochlorite;
b) chlorhexidine bigluconate;
c) EDTA;
d) ether;
e) iodides.

19. The thickness of the smear layer formed during root canal preparation is:
   a) 1–2 microns;
   b) 100–200 microns;
   c) 0.4–0.8 microns;
   d) 40–80 microns;
   e) 80–100 microns.

20. Antimicrobial activity of chlorhexidine is most high at pH value:
   a) 1–2;
   b) 11–12;
   c) 5.5–7.0;
   d) above 7;
   e) 3–5.

21. Sodium hypochlorite has the following effects:
   a) antimicrobial;
   b) lysing (dissolving);
   c) bleaching;
   d) hemostatic;
   e) chelating.

22. EDTA has the following effects:
   a) antimicrobial;
   b) lysing (dissolving);
   c) bleaching;
   d) hemostatic;
   e) chelating.

23. Iodides used in endodontics have the following effects:
   a) antimicrobial;
   b) lysing (dissolving);
   c) bleaching;
   d) hemostatic;
   e) chelating.

24. Agent used at the beginning of the medical treatment of root canals is:
   a) sodium hypochlorite;
   b) chlorhexidine bigluconate;
   c) EDTA;
   d) hydrogen peroxide;
   e) iodides.

25. A substance with a lysing (dissolving) effect is:
   a) sodium hypochlorite;
   b) chlorhexidine bigluconate;
   c) EDTA;
   d) hydrogen peroxide;
   e) iodides.

26. The disadvantages of sodium hypochlorite when used in endodontics are:

a) the ability to cause corrosion of files;
b) bad smell;
c) the ability to irritate periapical tissues;
d) high toxicity in any concentration;
e) insufficient antimicrobial activity.

27. The causes of the "hypochlorite accident" are:

a) jamming of the needle in the canal;
b) incorrect determination of the working length;
c) incorrect irrigation technique;
d) usage of 5.25 % solution;
e) using an insulin syringe.

28. The lysing (dissolving) effect of sodium hypochlorite is expressed in the concentration:

a) 5 %;
b) 3 %;
c) 0.5 %;
d) 1 %;
e) 2 %.

29. The formation of parachloroaniline occurs when interacting:

a) sodium hypochlorite and distilled water;
b) hydrogen peroxide and sodium hypochlorite;
c) alcohol and EDTA;
d) EDTA and sodium hypochlorite;
e) chlorhexidine and sodium hypochlorite.

30. Methods of prevention of "hypochlorite accident":

a) determination of the working length of the root canal in dynamics;
b) diagnostic X-ray examination;
c) usage of 3 % sodium hypochlorite;
d) pre-administration of an antibiotic;
e) inactivation of sodium hypochlorite.

Keys to the test for self-control: **1** — c; **2** — a; **3** — b; **4** — b, c; **5** — c; **6** — a; **7** — a, c; **8** — d; **9** — a; **10** — c; **11** — b, c, e; **12** — a, b, c; **13** — a, c, e; **14** — b, c, d; **15** — b; **16** — c; **17** — a, c; **18** — a, c; **19** — a; **20** — c; **21** — a, b, c, d; **22** — a, e; **23** — a; **24** — a; **25** — a; **26** — a, b, c, e; **27** — a, b, c; **28** — d; **29** — e; **30** — a, b.

LITERATURE

Basic

1. *Терапевтическая* стоматология : учеб. для студентов медицинских вузов / под ред. Е. В. Боровского. Москва : Медицинское информационное агентство, 2011. 840 с.

2. *Луцкая, И. К.* Эндодонтия : практическое руководство / И. К. Луцкая, И. Г. Чухрай, Н. В. Новак. Москва : Мед. лит., 2013. 208 с.

3. *Бутвиловский, А. В.* Современные принципы эндодонтического лечения : учеб.-метод. пособие / А. В. Бутвиловский, И. А. Пищинский, А. И. Делендик. Минск : БГМУ, 2015. 34 с.

4. *Казеко, Л. А.* Ирригационные растворы, хелатные агенты и дезинфектанты в эндодонтии : учеб.-метод. пособие / Л. А. Казеко, С. С. Лобко. Минск : БГМУ, 2013. 48 с.

Additional

5. *Роудз, Д. С.* Повторное эндодонтическое лечение : консервативные и хирургические методы / Д. С. Роудз ; пер. с англ. Москва : Медпресс-информ, 2009. 216 с.

6. *Гутман, Д. Л.* Решение проблем в эндодонтии : профилактика, диагностика и лечение / Д. Л. Гутман, Т. С. Думша, П. Э. Ловдэл ; пер. с англ. Москва : Медпресс-информ, 2008. 592 с.

7. *Бер, Р.* Эндодонтология / Р. Бер, М. Бауман, С. Ким ; пер. с англ. ; под общ. ред. проф. Т. Ф. Виноградовой. 2-е изд. Москва : МЕДпресс-информ, 2006. 368 с.

8. *A review* on root canal irrigation solutions in endodontics / Z. Mohammadi [et al.] // JDMT. 2021. Vol. 10. P. 1–12.

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MEDICAL TREATMENT OF TOOTH ROOT CANAL SYSTEM

Учебно-методическое пособие

На английском языке

Ответственная за выпуск В. А. Андреева
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