МИНИСТЕРСТВО ЗДРАВООХРАНЕНИЯ РЕСПУБЛИКИ БЕЛАРУСЬ
БЕЛОРУССКИЙ ГОСУДАРСТВЕННЫЙ МЕДИЦИНСКИЙ УНИВЕРСИТЕТ
2-я КАФЕДРА ТЕРАПЕВТИЧЕСКОЙ СТОМАТОЛОГИИ

А. В. Бутвиловский, Т. Н. Манак, В. Р. Гайфуллина

СОВРЕМЕННЫЕ ПРИНЦИПЫ ЭНДОДОНТИЧЕСКОГО ЛЕЧЕНИЯ

MODERN PRINCIPLES OF ENDODONTIC TREATMENT

Учебно-методическое пособие

Минск БГМУ 2017

УДК 616.314.163-089.27(075.8)-054.6
ББК 56.6я73
Б93

Рекомендовано Научно-методическим советом университета в качестве учебно-методического пособия 21.06.2017 г., протокол № 10

Р е ц е н з е н т ы: канд. мед. наук, проф. Белорусской медицинской академии последипломного образования Н. А. Юдина; канд. мед. наук, доц. Белорусской медицинской академии последипломного образования С. А. Гранько; канд. филол. наук, доц. Белорусского государственного медицинского университета М. Н. Петрова

Бутвиловский, А. В.

Б93 Современные принципы эндодонтического лечения = Modern principles of endodontic treatment : учебно-методическое пособие / А. В. Бутвиловский, Т. Н. Манак, В. Р. Гайфуллина. – Минск : БГМУ, 2017. – 28 с.

ISBN 978-985-567-811-4.

Изложены основные принципы и правила эндодонтического лечения, его этапы, критерии оценки эффективности, возможные ошибки и осложнения, а также врачебная тактика при их возникновении.

Предназначено для студентов 5-го курса медицинского факультета иностранных учащихся, обучающихся на английском языке.

УДК 616.314.163-089.27(075.8)-054.6
ББК 56.6я73

Учебное издание

Бутвиловский Александр Валерьевич
Манак Татьяна Николаевна
Гайфуллина Виктория Радиковна

СОВРЕМЕННЫЕ ПРИНЦИПЫ ЭНДОДОНТИЧЕСКОГО ЛЕЧЕНИЯ

MODERN PRINCIPLES OF ENDODONTIC TREATMENT

Учебно-методическое пособие

На английском языке

Ответственная за выпуск Т. Н. Манак
Переводчик А. В. Бутвиловский
Компьютерная верстка Н. М. Федорцовой

Подписано в печать 08.09.17. Формат 60×84/16. Бумага писчая «Снегурочка».
Ризография. Гарнитура «Times».
Усл. печ. л. 1,63. Уч.-изд. л. 1,36. Тираж 99 экз. Заказ 634.

Издатель и полиграфическое исполнение: учреждение образования
«Белорусский государственный медицинский университет».
Свидетельство о государственной регистрации издателя, изготовителя,
распространителя печатных изданий № 1/187 от 18.02.2014.
Ул. Ленинградская, 6, 220006, Минск.

ISBN 978-985-567-811-4

MOTIVATIONAL CHARACTERISTICS OF THE THEME

The theme of the seminar: Modern principles of endodontic treatment. Tools and materials for filling root canals.

Total time: seminar 7 academic hours.

Nowadays diseases of pulp and apical periodont are the main causes for teeth extraction.

Endodontia is one of the most difficult parts in therapeutic dentistry. Significant difficulties of endodontic treatment are created by a variety of nosological forms of diseases of pulp and apical periodont, complication and variability of anatomy of root canal's system, variety of approaches to mechanical and medical preparation of endodont and methods of postendodontic recovery of the tooth.

The correct planning of endodontic treatment, knowing and detailed following its basic principles, timely and effective recovery of anatomical tooth wholeness are the factors which define to a great extent success of treatment of pulp diseases and apical periodont diseases.

In recent years plenty of publications dedicated to endodontic treatment have appeared. It was connected with creating new systems for mechanical preparation of root canals, medicines for killing microbes and materials for obturation of root canal system.

The reasons mentioned above define the necessity to generalize and make into a system a great number of information about the principles and stages of endodontic treatment in this study guide.

The purpose of the seminar: to integrate knowledge of basic principles of endodontic treatment.

The tasks of the seminar. As a result every student must know:

– modern principles of diagnosis and treatment of pulp and apical periodont diseases;

– anatomy of pulp cavity and root canal system;

– criteria of efficiency of endodontic treatment.

Requirements to the initial level of knowledge. For full acquisition of the topic the student must revise:

– human anatomy: anatomy of teeth, pulp, periodont;

– histology, cytology, embryology: development and terms of eruption of deciduous and permanent teeth;

– normal physiology: physiological functions of tooth, pulp and periodont;

– pathological physiology: mechanisms of pain occurrence in dental disoders.

Control questions from the allied subjects:

1. Endodontic instruments.
2. Methods of root canal treatment
3. Materials and tools for obturation of root canals.
4. Methods of obturation of root canals.

Control questions referred to the seminar:

1. Anatomy of tooth and root canals of all teeth groups.
2. Characteristics of nosological forms (according to the international classification).
3. Methods of diagnosis of pulp and apical periodont diseases.
4. Basic principles of endodontic treatment.
5. Tools for mechanical preparation of root canals.
6. Technique of root canal's preparation.
7. Emergency care in endodontics.
8. Assessment criteria of endodontic treatment efficacy.

PURPOSE, STAGES AND QUALITY STANDARD OF ENDODONTIC TREATMENT

The purpose of endodontic treatment is to preserve functional value of tooth.

Endodontic treatment includes the following stages:

1. Planning.
2. Anaesthesia if necessary.
3. Isolation of the working field.
4. Creating endodontic access.
5. Defining working length.
6. Medical and mechanical preparation of root canal system.
7. Verification of working length.
8. Obturation of the system of root canals.
9. Restoration of tooth crown.
10. Control of long-term results.

Modern quality standards of endodontic treatment are based on the following postulates:

– All healing manipulations must be painless.

– Strict following of aseptic and antiseptic rules.

– Root canal must be prepared and filled along the entire length.

– Mechanical and medical preparation and cleaning of root canal must be carried out compulsory not regarding to the diagnosis (pulpitis, periodontal disease, depulpation and etc.)

– During preparation the canal must be widened not more than two file numbers, apical part — not less than 25(35) according to ISO.

– Root canal must be obturated using fillers and sealers.

– Root filling must pack the canal and be placed at the level of physiological apex of the root.

PLANNING OF ENDODONTIC TREATMENT

The first step of endodontic treatment is defining the diagnosis which is carried out with getting complaints and case history, evaluating clinical situation and using additional examination techniques:

– X-ray examinations;

– temperature test;

– electric pulp test.

X-ray diagnosis refers to additional methods but it is compulsory during endodontic treatment.

During the process of endodontic treatment 4 X-rays for one tooth are made:

– for diagnosis;

– for defining working length;

– for confirmation of treatment quality;

– for evaluation of treatment quality in long terms (6–12 months).

In some cases it is necessary to control radiologically fitting of gutta percha point.

The description of tooth X-ray includes objective and subjective parts.

Objective part (establishment): symptoms of radiolucency and blackening in description of dental crown, roots, canals, the field of furcation, periapical area, preservation of cortical bone, bone volume andbone density.

Subjective part: it is necessary to correlate clinical symptoms with the objective part of X-ray research.

The ideal method of X-ray examination at the stage of endodontic treatment planning is dental computer tomography. This method has several advantages compared to dental panoramic radiogram:

1. High informativity of getting image (the number and the shape of root canals, anatomical location of apical hole, presence of delta-shaped branches, inflammatory changes in apical periodont, assessment of root canal filling).

2. Possibility of accurate measurement of anatomic structures.

3. Possibility to study any element of jaw-face area in any section.

Disadvantages of this method of diagnosis are supposed to be a higher cost and a little bit higher radiation dose in comparison with digital orthopantomography.

The most informative method of X-ray research during endodontic treatment is long-focused X-ray filming (X-ray filming by parallel rays).

The most popular method of X-ray research in Belarus is intraoral contact X-ray filming in isometrical view.

Long focused X-ray filming (X-ray filming by parallel rays, fig. 1) is based on a significant distance of X-ray tube from the shot object. In this case the angle of X-ray spreading in projection on the object becomes minimal (parallel ray). It helps to minimalize mistakes. Nowadays it is made with the help of bracket gauge, making perpendicular between the X-ray tube and the X-ray film.

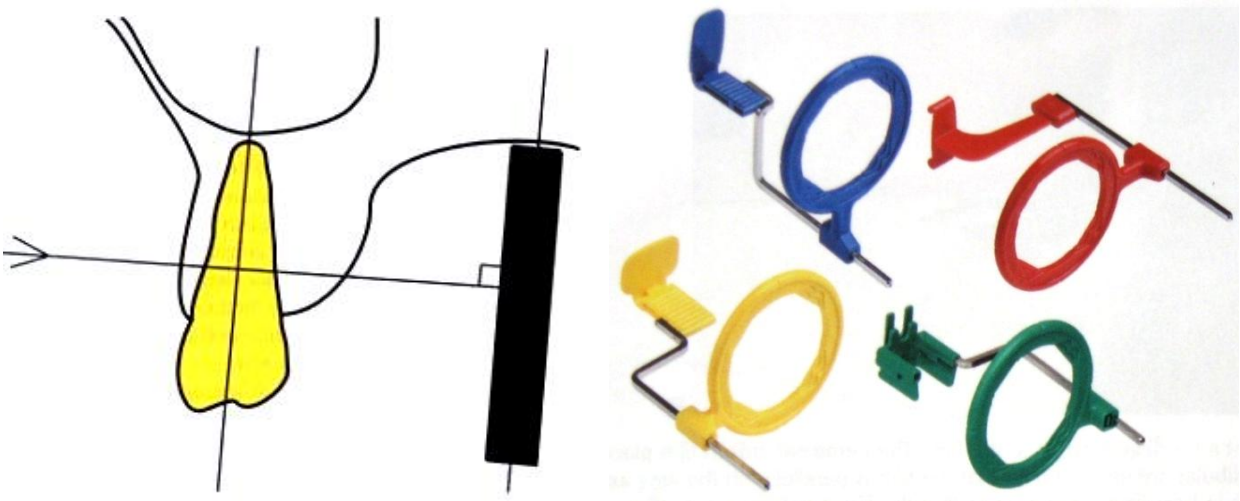

Figure 1. The scheme of carrying out long-focused X-ray filming and basic types of bracket gauges

Making intraoral X-ray in isometric projection (fig. 2) the ray is directed perpendicularly to bisector of angle between the film and long axis of the tooth.

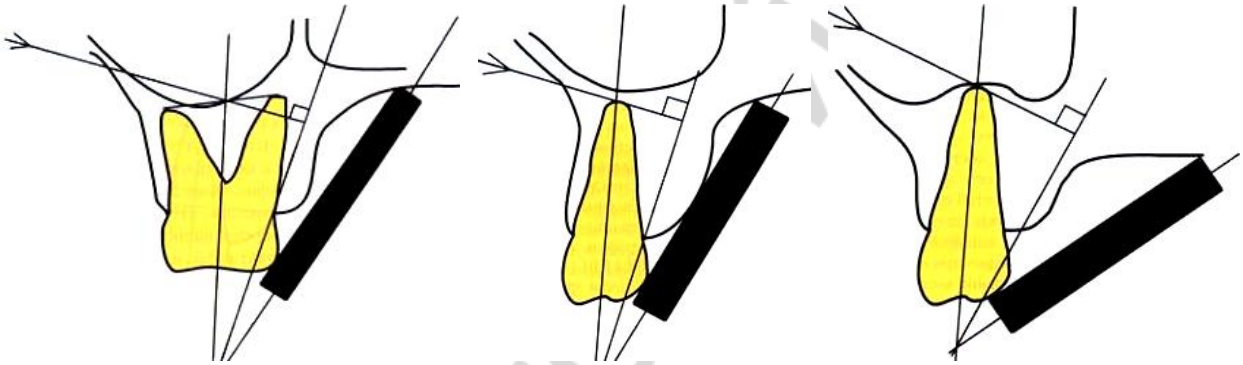

Figure 2. The scheme of carrying out intraoral X-ray in isometric view

Note. As X-ray image is flat image of three-dimensional object, the layering the tooth parts on each other is possible. Exact assessment of dental root condition is especially difficult at oral and labial position because of their layering on each other. For visualization of these tooth parts we can make angle misplacement of tubus emitter into mesial and distal sides.

Defining tooth sensibility to temperature and electric stimulus can inform us about pulp condition. However, as a rule, it is impossible to differentiate the vital pulp from reversible or irreversible pulpitis only with the help of this test as intact nerve tissue can be revealed even in the areas of well-marked necroses. In some cases sensor tests occur to be positive having destruction of osteal tissue in apical periodont (Lin et al., 1984). Nevertheless, with the help of these tests defining the state of pulp is usually done that's why these tests are also known as «vitality tests».

Cold test is considered to be the most informative. Ice cubes, chlorethyl, frigen (the American equivalent of freona), dry ice (carbon dioxide snow) can be used for this test. According to research Lutz et al. (1974) application of cold for 4 seconds lowers the temperature of tooth to 26–30 °C, provoking a painful

reaction. The temperature of pulp goes down only on 0.2 °C in this case. The ice cubes provides the temperature about 0 °C, frigen which is made in the form of spray and applied with the help of a cotton pad to the cervical part of the tooth, tol –40 °C, dry ice reaches the temperature –70 °C. Cold test by dry ice has an advantage over the others. Thanks to the isolated layer of steam which is made from this substance at the temperature above 0 °C, this test doesn't harm the tooth or surrounding tissue. The tooth enamel is not cracked even during 2 minutes contact with dry ice (Peters et al., 1986).

Sensibility of the tooth to hot can be assessed using preheated gutta-percha (pads with raised temperature of melting point, not posts) or heated wax.

Thus, it is necessary to note that the widely-spread method of defining tooth sensibility to cold with the help of air or water stream isn't significantly informative. In any case, it's necessary to remember that dental cervix is the most sensitive part of the tooth reacting to cold. The thickness of hard tissues in this area is minimal, therefore the possibility to get an objective responce of pulp to the hot influence is higher.

Checking of pulp electroexcitability is known as an electric pulp test. It is based on unique relative conduction of hard tooth tissues. The device makes the series of impulses of regulated tension, tuned to resistance of tooth tissue. As it was with the temperature test, differential diagnosis of diseases is complicated. It is possible to define vitality with the help of the electric pulp test. Differential diagnosis of different forms of pulpitis with the only help of electric pulp test is unlikely. A more informative index is a comparative assessment of tooth pulp electroexcitability from one anatomy group or comparing such teeth from the opposite side.

The electric pulp test is widely used for dynamic assessment of the pulp state. For example, assessment of pulp vitality after dental trauma.

It is necessary to consider the following conditions which can misinterpreted the data of the electric pulp test.

– when anesthesia was made;

– if a patient has taken pain killers, tranquilizers, alcohol, drugs;

– when the formation of root is not completed or it has resorption;

– after recent dental trauma;

– if the tooth has a big carious defect or a big restoration;

– at inadequate contact with enamel (through restoration material);

– in case of development of degenerative processes in the pulp, calcifications;

– if a patient reacts to pain inadequately (kids, people with mental disorders);

– at partial pulp necrosis when in some canals the pulp is vital and in others the pulp is unvital;

– if the tooth is covered with a metal (a short electric chain is made) or ceramic crown (electric chain is stopped).

The electric pulp test is forbidden for patients with artificial heart by-pass.

Defined diagnosis including the overall patient's condition and available materials enables to define the method of endodontic treatment.

Conservative methods:

– *indirect covering of pulp*;

– *direct covering of pulp.*

Surgical methods:

– *pulpotomia (vital and devital)*;

– *pulpectomy (vital and devital).*

When planning endodontic treatment it is necessary to know the factors the successful result depends on.

1. Multiplicity of treatment.
2. Presence of periapical changes.
3. Knowledge of anatomy.
4. Materials and equipment (including light and magnification).
5. Skills of anthe operator.
6. Isolation of working field.
7. Quality and depth of preparation (not < 2 mm till root apex).
8. Density of root canal system filling.
9. Hermetic state of restoration.

At the stage of endodontic treatment planning the most important success factors are multiplicity (initial or repeated treatment), presence or absence of periapical changes (table 1).

Table 1

Dependence of endodontic treatment success on multiplicity and presence of periapical changes

Multiplicity of treatment	Periapical changes	Success
Initial	–	83–100 %
	+	46–93 %
Repeated	–	89–100 %
	+	56–84 %

Nowadays the preference is given to one-visit endodontic treatment.

The objective clinical indices for treatment in several visits are MTA usage and marked exudation after mechanical and medical preparation of the root canal system, not enabling to provide dryness and consequently to carry out the permanent filling.

There are subjective factors defining treatment in several visits such as material (absence of equipment and tools), temporal (lack of time) and operant cognitive (absence of necessary knowledge and skills of operator).

ISOLATION OF WORKING FIELD

The classic means of isolation of working field in endodontics is a rubber dam which has the following advantages:

1. Possibility of tooth isolation from moistness of breathed air and oral liquid.
2. Possibility of tooth isolation from aggressive microbial environment in the mouth cavity, i.e. practical realization of septic and antiseptic rules.

3. Decreased influence of high temperature in the mouth cavity on penetration and cure of materials.

4. Improvement of approach to inconveniently located teeth and tooth surfaces.

5. Protection of the working field from the tongue and lips of the patient.

6. Improvement of the doctor eye control under manipulations including concentration of attention on an object of interference.

7. Protection of the patient against an unpleasant taste of using medicines.

8. Protection of the oral mucosa of the patient from aggressive medicines.

9. Better patient management.

10. Saving time at carrying out procedures.

At the same time the application of a rubber dam at endodontic treatment has some disadvantages:

1. Loss of axial landmark on creating endodontic access.

2. Possible injury of the oral mucosa.

3. Difficulties at X-ray examination (necessity to remove the latex screen before carrying out each shot.

4. Possible allergy.

Important addition to isolation of the working field with the help of a rubber dam is the technique of four walls which enables to minimize the contact of the root canal system with the mouth liquid. Nowadays there are several options of the procedure.

– saving tooth walls;

– preservation fragments of hermetic restorations as walls;

– making temporary restoration with consequent creation of endodontic access through it;

– application of copper and orthodontic rings;

– making up a temporary crown with consequent creation of endodontic access through it.

Choice of four walls technique is defined by the level of tooth destruction, presence of hermetic restorations and planning term service of temporary construction.

Initially glass-ionomer cementum (GIC) has good edge adjacency but grinding and disorder of edge adjacency can be noticed in length of time which allows to use it even mixed with rings for short-term temporary constructions. Usage of composite crowns fixed on adhesive cementum is possible only for 1–3 months. Metal crowns with plastic covering can be installed for 2 years.

CREATION OF ENDODONTIC ACCESS

Basic principle of creation of endodontic access is exsection of all tissues in the crown part of the tooth which complicate direct access to root canal orifices.

Stages of creation of endodontic access are:

1. Preparation of carious cavity (removing old non-hermetic restorations).

2. Opening of pulp cavity.

3. Opening of pulp cavity with removing dentin coves.
4. Search of canal orifices.
5. Creation of straight line access.

Preparation of the carious cavity and opening of the pulp cavity are made with a circular-shaped diamond bur, locating it in a parallel way to long tooth axis. Access is formed starting from the crown center and farther, moving the bur towards the largest pulp area (it is located over the orifice of the largest canal).

To open the pulp cavity and remove the dentin coves we usually use EndoAccess (Dentsply) and a cylindrical or conical bur with a rounded non-aggressive top (fig. 3).

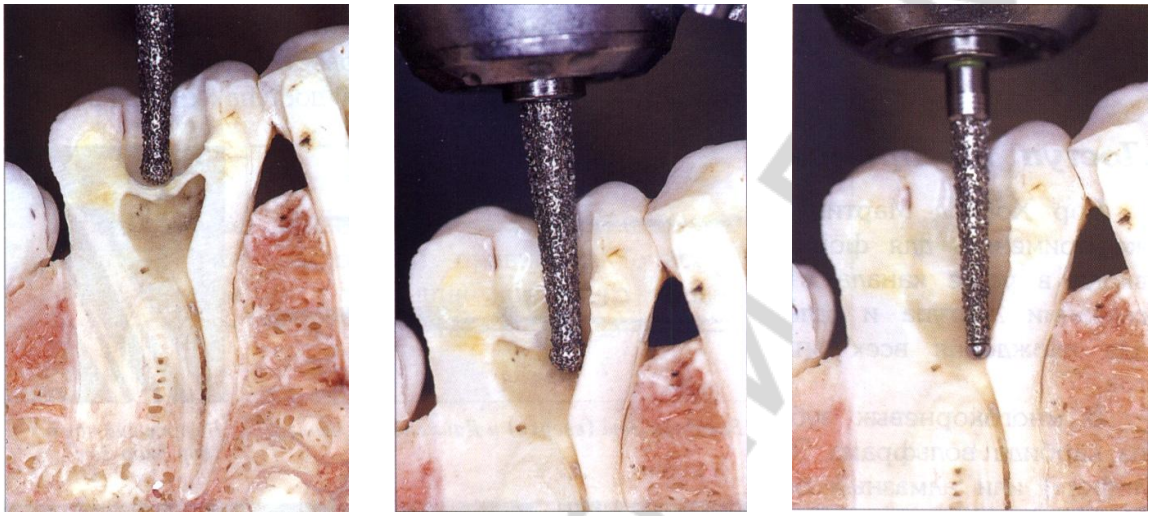

Figure 3. Stages of pulp chamber opening

Complete removal of the pulp roof and dentine coves provides an adequate view of the pulp cavity bottom. The bottom of the pulp cavity has protrusions and deepenings in which root canals` orifices are located. The search is carried out with the help of a thin hard dental probe and a thin file.

When creating endodontic access it is reasonable to use ultrasonic system (endodontic sets «NSK», «Satelec», «StartX» of «Dentsply», table 2).

Table 2

Intended Purpose of Ultrasonic Top Sets StartX

StartX	Characteristics	Intended purpose
1	Active side part, non-active rounded top	Polishing of tooth cavity walls
2	Active side part, active rounded top	Removal of calcificates in pulp cavity
3	Active pointed tip	Removal of calcificates and dentin in cervical part of canal
4	Active bulbous-end tip	Removal of broken files
5	Thin cylindrical tip	Cleaning of pulp chamber bottom

Root canals, as a rule, have a marked bending. Decrease of root canal angle allows to create a straight line access, so significantly reduces the possibility of breaking files in the root. Such tools as Protaper SX («Dentsply»), Largo, Gates Glidden and X-Gates can be used for decreasing root canal angle.

DEFINING OF WORKING LENGTH

Defining of working length (distance from the most outpouching tooth part to physiological constriction) is a separate stage of endodontic treatment. The working length is very variable (fig. 4).

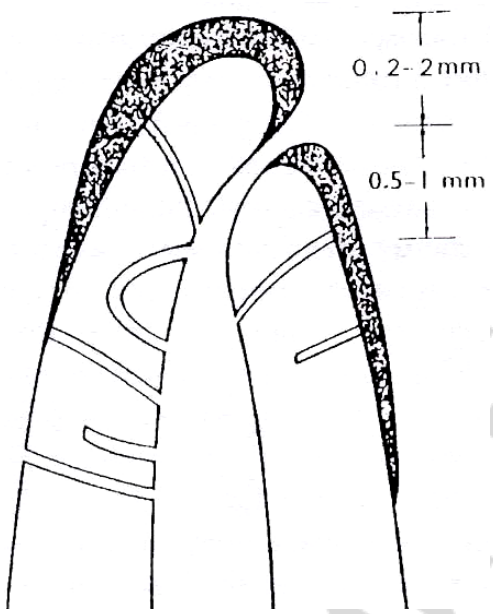

Figure 4. Scheme of apex of root canal

The medico-mechanical preparation of canals within physiological constriction has the following advantages:

– prevents traumatizing periapical tissues;

– minimizes propulsion of microbes, filler and sealer behind the apex;

– provides optimal depth of canal filling.

For passing the root canal it is necessary to use thin files, preferably files-catheters (C-files) № 6, 8, 10, 15 (18, 21, 25 mm).

The basic methods of defining working length can be divided into:

● Investigatory:

– diagnostic X-ray;

– tables of average length;

– manual;

– golden ratio.

● Verificatory:

– X-ray with the files;

– *physical (apex locators).*

Apex locators of latest generation measure impedance while passing electricity of 2 different frequencies. They work in humid environment with the presence of electrolytes, don't require gauging and tuning corrector (Formatron D10, Precise Apex Locator, Root XS 7.67).

● Combined.

The algorithm of actions at defining working length includes 3 steps:

– Intake of a file at length on 1.5–2 мм less than on the diagnostic X-ray.

– Verification using apex locator.

– Verification using X-ray.

The working length is considered to be set if a file doesn't reach X-ray top 0–2 mm and the farther root canal isn't visible.

MEDICAL AND MECHANICAL PREPARATION OF ROOT CANAL SYSTEM

The tasks of medical and mechanical preparation of root canal system are:

– removal of infected tissues;

– extermination of microbes;

– enlargement of root canal saving its anatomic form and creation of conditions for consequent filling.

The 2 concepts of canal preparation have been suggested, each of them hasving some disadvantages (table 3).

Table 3

Concepts of root canal preparation and their disadvantages

Concept of canal preparation	Disadvantages
Apical preparation	1. Apical weakness. 2. Difficulties of application in curved canals. 3. Bad conditions for irrigation
Coronal preparation	More expensive (with special files usage) or need more time

Mechanical treatment is carried out by two approaches: from crown to apex or from apex to crown. For treatment from crown to apex machine-type files are used (ProFiles, GT-rotary files, ProTaper, WaveOne, FlexMaster, Ptrotaper Next, WaveOne Gold) as well as manual tools (Protaper). For treatment from apex to crown manual files are used.

Rules of medical and mechanical preparation:

– Wastefulness: single usage of small size files, refusal from using files with visual stress indication.

– Cleaning of files before repeated intake into root canal.

– Assessment of file condition before repeated intake into root canal.

– Usage of flexible files and pre-curving of rigid files.

– Returning to the previous file.

– Frequent instillation of root canal system.

– Abidance of exposition and sufficient amount of solutions for medical treatment.

The technique of «carpet path» provides maximum saving of the anatomical canal shape. It is used before preparation by machine shaping and forming files and includes consequential use of Pathfile № 1, 2, 3 («Dentsply», fig. 5).

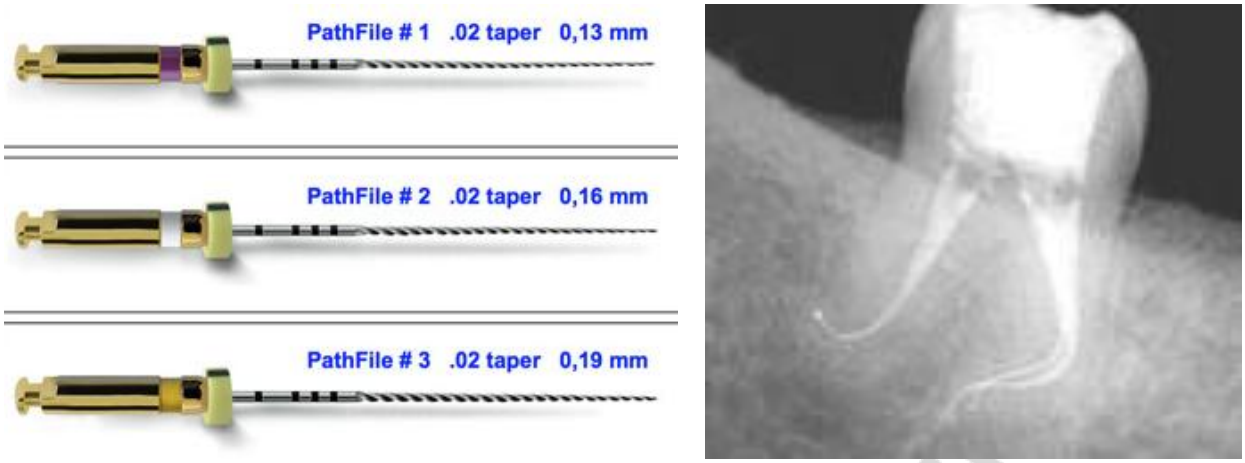

Figure 5. Files for creation of carpet path (Pathfiles № 1–3; on the left) and their usage for saving root canal anatomic shape (Courtesy of Dr. F. Santarcangelo, Barl.; on the right)

Creation of carpet path with the help of one tool, possibly with the help of Proglider, which has the top diameter 0.16 mm (2 %) and increasing taper.

Nowadays the system Protaper («Dentsply») has an extensive use in Belarus. It has the following basic characteristics:

– preparation from crown to apex;

– creating conditions for good irrigation;

– variable taper with increasing taper on the area where an intensive file work is needed;

– presence of machine-type and manual variants;

– presence of files for unfilling (D1-D3), calibrated paper and gutta-percha points.

Files of Protaper system for canal treatment (fig. 6) can be devided into 2 groups:

1) shaping (has shape of the Eiffel tower, non-active tops:

SX (apical diameter 19 mm, 4 %);

S1 (apical diameter 18 mm, 2 %);

S2 (apical diameter 20 mm, 4 %);

2) *finishing* (has the shape of obelisk):

F1 (apical diameter 20 mm, 7 %);

F2 (apical diameter 25 mm, 8 %);

F3 (apical diameter 30 mm, 9 %);

F4 (apical diameter 40 mm, 6 %);

F5 (apical diameter 50 mm, 5 %).

The standard work sequence using Protaper system includes the following stages:

1) passing of the canal by K-file № 10 and № 15 and Protaper S1 on 2/3 of length;

2) preparation of cervical third of canal by Protaper SX (4–5 mm from orifice);

3) verification of working length;

4) preparation of canal by K-file № 10 and № 15 and Protaper S1 on entire working length;

5) preparation of canal by Protaper S2 on entire working length;

6) preparation of canal by Protaper F1 on entire working length;

7) in case of apical stop absence — consequential preparation of canal on entire working length by Protapers F2, F3, F4, F5 till its formation.

Figure 6. Range of manual files system Protaper (SX, S1, S2, F1-F5)

Protaper Next files have the following characteristics:

– dissymmetric transection with decenter increases endurance of file and creates space for removal of dentin cuttings;

– M-Wire nickel-titanium alloy technology enlarges flexibility and increases endurance of files;

– wavy movement of file enlarges cutting efficiency;

– smaller top size and taper provide conservative preparation of apical third of root canal.

The system Protaper Next consists of 5 unique files:

X1 (apical diameter 17 mm, 4 %);

X2 (apical diameter 25 mm, 8 %);

X3 (apical diameter 30 mm, 7.5 %);

X4 (apical diameter 40 mm, 6.5 %);

X5 (apical diameter 50 mm, 6 %).

Protaper Next X1 takes functions of two forming files system Protaper (S1 and S2) and X2 — two finishing files (F1 and F2).

The main agents for medical treatment in endodontics are sodium hypochlorite and EDTA (table 4).

Sodium hypochlorite (concentration not less than 1 %) has proteolytic activity and dissolves pulp and dentin matrix elleviating preparation of root canal mechanically. Moreover, it has a bactericidal effect on a wide range of gram-positive and gram-negative bacteria, fungus and viruses. Oxidation of pigments

(formed during pulp necrosis or hemorrhaging) by sodium hypochlorite provides a bleaching effect and makes it effective to correct tooth discoloration.

Table 4

Basic agents for medical treatment of root canals system

Active substance	Agents	Effect
Sodium hypochlorite 0.5–5.25 %	Milton (3 %) Parkan (3 %) Belodez (3 %) Hypohloran (3.5 %) Biocept C (3 %)	– antibacterial; – necrolytic; – removal of smear layer; – bleaching
EDTA 15–19 %	EDTA solution (17 %) Largal Ultra (15 %) Endozhi № 2 (15 %) Glyde (15 %)	– removal of smear layer; – softening of dentin; – antibacterial
Iodide	Iodinol Churchill solution	– antibacterial
Chlorhexidine 0.05–2 %	Chlorhexidine 0.05 % Korsodil (0.2 %) Consepsis (2 %) Belsol № 2 (2 %)	– antibacterial

Concentration of sodium hypochlorite for usage in endodontics varies from 0.5 to 5.25 %. Usage of sodium hypochlorite in high concentration is recommended for pulp cavity and cervical third of canal, usage in low concentration — for apical part of canal especially in case of wide apical opening. Concentration of sodium hypochlorite equal to 3 % is the most universal that's why most producers prefer to make 3 % solution of sodium hypochlorite.

Sodium hypochlorite is stabilized by 0.5 % solution of sodium bicarbonate for decreasing harmful effect of sodium hypochlorite on tissues due to alkaline reaction. It allows to decrease pH without changing antibacterial properties.

The smaller the concentration of sodium hypochlorite is used, the faster the solution is inactivated and the more frequent instillation is necessary.

EDTA (ethylene diaminetetraacetate) provides softening of dentin on root canal walls at the depth 20–50 mkm by chelating calcium ions, thereby making mechanical preparation easy. Moreover, EDTA effectively removes smear layer, opens dentin tubes and therefore creates conditions for penetration of sealer. EDTA has an affinity to iron ions what leads to biofilm destruction due to creation of chelate bonds.

EDTA is produced in concentration 17 % in the form of fluid or gel buffered to neutral pH value.

Manufacturers often combine EDTA with other active substances:

– quaternary amine (antiseptic) — «Largal Ultra» («Septodont»);

– hydrogen peroxide (antiseptic, bleaching agent) — «Canal+» («Septodont»);

– carbamide peroxide (antiseptic, bleaching agent) — «Glyde» («Septodont»).

Algorithm of medical treatment is shown in fig. 7.

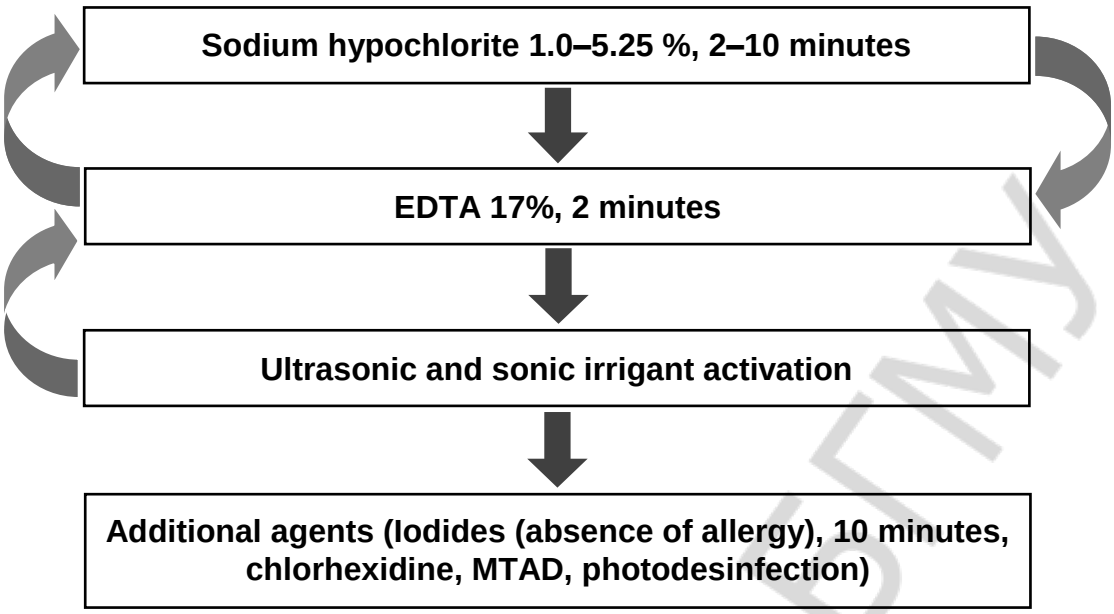

Figure 7. Algorithm of medical treatment of root canal system

According to this algorithm duration of medical treatment is about 30–45 minutes, it exceeds the time necessary for mechanical treatment.

The main directions to decrease duration of medical treatment are:

– frequent change of agents;
– increasing of the solution volume;
– heating up to 37 °C;
– using of detergents;
– ultrasonic and sonic irrigant activation;
– bigger widening of canal and making conical shape.

Instillation of root canal must be done at maximum depth within root canal system and accompanied by in-and-out movements. Endodontic needles must have a round and blunt top and side openings (preferable — two-side openings) at a distance less than 3mm from the top. Nowadays it becomes popular to use telescope-type flexible endodontic needles.

Most injectors have Luer Lock for reliable connection between an endodontic needle and an injector.

Temporary filling of root canals can be considered as a type of medical treatment whereas it allows to:

– eliminate microbes;
– support a canal in disinfecting condition between visits;
– destroy organic remains in root canal;
– lower acidity in the area of inflammation.

It is important to note that it is difficult to put calcium hydroxide into narrow and curved root canals, so we need to preparate them in advance.

Calcium hydroxide is mixed on distilled water, addition of glycerin increases its liquidity but lowers pH.

For a temporary filling 2 groups of agents are used:

– agents containing **$Ca(OH)_2$**: «Calcium hydroxide» («Dental thepapeutics AB»), «Calxyl» («OCO»), «Calcicur» («Voco»), «Metapasta» («Meta»), «Apexdent» («VladMiVa»);

– agents containing **$Ca(OH)_2$** and **iodoform**: «Metapex» («Meta»), «Apexdent with iodoform» («VladMiVa»).

There are 3 ways of putting of calcium hydroxide into root canals:

1) using manual files;
2) with the help of Lentulo spiral (500–800 rot/min), which has a stopper;
3) through a disposal cannula.

Preferable time for calcium hydroxide staying in root canal is from 1 week (minimum time of activity) to 4 weeks (agents on water base are dissolved).

VERIFICATION OF WORKING LENGTH

After mechanical treatment of canal small curvature it becomes more direct, so the working length is decreased by 0.5–3.0 mm.

Verification of working length must be done during the process and after preparation of curved root canals, because possible destruction of physiological constriction leads to breaking tools (fixation of apical part of the file), traumatizing of periapical tissues, their contamination and extrusion of filling materials.

The method of choice for verification working length is physical (usage of apex locator).

OBTURATION OF ROOT CANAL SYSTEM

Tasks of root canal obturation are:

– to remove connection between the root canal and the crown part of the pulp cavity;

– to isolate microbes left in basic and additional root canals;

– to prevent tissue liquid passing into the canal.

For obturation we need a filler (nowadays gutta-percha is preferred) and a sealer. Advantages of gutta-percha are:

1. Inactive.
2. Space stable.
3. Doesn’t cause allergy.
4. Doesn’t color dentin.
5. Radio-opaque.
6. Compressible.
7. Softens during heating.
8. Softens by organic dissolvers.
9. Removed from root canals if necessary.

There are two types of gutta-percha:

1) β-gutta-percha has a high point of melting, bad sticking and good flexibility;

2) α-gutta-percha has a low point of melting, good sticking, viscosity.

Functions of sealer:

– fills micro spaces and dentin canals;

– smoothes canal walls;

– provides gliding of gutta-percha points.

The sealer is a weak part at canal obturation, so its amount must be minimum. The groups of sealers:

– resin-based (AH Plus, Acroseal, EndoRez);

– MTA-based (Filapex);

– silicon-based (RoekoSeal, GuttaFlow);

– glass ionomer cement (Ketac Endo, Endoseal);

– zinc-oxide eugenol cement (Roth, Kerr PCS, Endomethasone N, Canason);

– containing calcium hydroxide (Sealapex, Apexit);

– dentin-adhesive based (Epiphany).

Nowadays resin-based sealers are widely-used. Their advantages are biocompatibility, low viscosity and suitable working time. The disadvantages of this sealer group are sensibility to humidity (before filling the canal must be dried ideally), sensibility to remains of oxidizing agents in canals (the last instiller mustn't be oxidizer), postfilling pains when the sealer goes through the apex (it is necessary to make dynamic verification of the working length).

MTA (mineral trioxide aggregate) is modification of portland cement which is widely used in construction. MTA includes tricalcium silicate ($3CaO \cdot SiO_2$), belit ($2CaO \cdot SiO_2$), tricalcium aluminate ($3CaO \cdot Al_2O_3$) and bismuth oxide for radio-density. Indications for MTA usage are indirect and direct pulp covering, apexogenesis and apexification, perforation closure, retrograde filling and obturation of apical third of the canal with periapical lesion. Time of MTA hardening is 2.45–4 hours. The most widely used MTA in Belarus is ProRoot MTA (Dentsply) and its generic Rootseal (GIAP).

One of the most popular MTA-based sealers in the world is Fillapex. It is based on salicylic acid. It hardens during 2 hours. Advantages: biocompatability, good hermetic properties, low viscosity, suitable working time, stimulates bone regeneration (40 % MTA in paste B). Disadvantages: sensibility to humidity.

The methods of filling root canals system can be classified as:

1. Cold gutta-percha:

– lateral condensation;

– chemical plastification (eucalyptol).

2. Preheated gutta-percha:

– vertical condensation;

– thermomechanical condensation (ultrasound or guttacondensor).

3. Thermoplastified gutta-percha:

– injection of gutta-percha (ultrafil);

– core gutta-percha (thermafil, guttacore).

Nowadays the method of lateral condensation is frequently used and it has the following stages:

1. After finishing of medical and mechanical treatment the root canal is dried with paper pin and master gutta-percha point is fitted. Its size must be equal to the master file and must enter the root canal at the working length swimmingly. If the point doesn't reach the working length it is necessary to repeat mechanical treatment by master file (with consequent instillation and drying) or fit the point of smaller size. If necessary you can make the X-ray with master point.

2. The sealer is put into the root canal system with the help of master-file, by master point or Lentulo spiral (with a stopper at working length).

3. The master point is inserted and pushed laterally by a spreader. The spreader (with a stopper set at the working length) is inserted not more than at working length. Then we move out the spreader by rotatory motions on 1/4 returns to leave the point inside the canal.

4. Additional points are inserted into the root canal (preferably with a bigger taper — 4, 6 and 8 %), preliminary covered with a sealer. Each of them is condensed as well as the master point. Additional points are inserted until the spreader will enter the root canal by more than 2–3 mm.

5. The remains of gutta-percha are removed at the level of the root canal orifice by a hot tool and vertical condensation is carried out by a small plugger.

6. The X-ray control must be done. If it is not done immediately, the tooth must be covered with temporary filling material.

The system «Gutta Core» enables to insert preheated gutta-percha on obturators from cross-linked gutta-percha.

The stages of the technique are:

1. Gutta core size verifier is inserted into the canal and rotated 360 degrees at working length.

2. The sealer is put on the walls of the root canal. The protruding substance of the sealer is removed by a paper pin.

3. The gutta-percha is placed into a special oven Thermaprep 2 and heated till gutta-percha has liquid consistence.

4. The point is inserted into the root canal avoiding contacts with its walls at the working length.

5. The handle of the obturator is removed by bending the handle in both sides from the canal or using a bur or a sharp excavator.

RESTORATION OF TOOTH CROWN AND CONTROL OF TREATMENT RESULT

Postendodontic tooth recovery can be carried out by making restoration or crown. Restoration of high quality provides safety of root filling and as a result defines the result of treatment.

Criteria of successful treatment:
– relieving pain and mobility of tooth (or decreasing these symptoms);
– absence of hyperemia and edema of soft tissue;
– closing of fistula;
– sufficient condition of restoration;
– full tooth functioning.
Criteria of failed outcome of treatment:
– persisting feeling of pain and increase of tooth mobility;
– hyperemia and edema of soft tissue around the tooth;
– presence of fistula;
– insufficient condition of restoration;
– gentle using of tooth during chewing.

X-ray control after tooth treatment without periapical changes is made once a year during 3–4 years. X-ray control after tooth treatment with aggressive lesion in the apex is made every 6 months during 3 years.

Suitable X-ray criteria (fig. 8):
1. Dense 3D obturation of root canal to the apex.
2. Normal thickness of periodontal hole (till 1 mm).
3. Presence of reparative processes in periapical part.
4. Holistic compact bone of alveolus.
5. Absence of resorption.

Figure 8. Dubious (on the left) and suitable (on the right) X-ray criteria of endodontic treatment

Dubious X-ray criteria are:
1. Widening of the periodontal hole (till 2 mm).
2. Absence or insufficient recovery of bone tissue.
3. Destruction of the compact bone.
4. Features of progressive resorption.
5. Emptiness in root filling, especially in apical third.
6. Significant pulling out of the filling material through the apex.

ERRORS IN ENDODONTIC TREATMENT AND THEIR COMPLICATIONS

Errors and complications	Causes	What to do?
File breakage	Failure of operation technique, loss of working length, file fatigue	To extract the broken file with the help of ultrasound, special systems and «by pass» technique
Perforation of pulp cavity bottom	Lack of knowledge about topography of pulp cavity, insufficient endodontic access, poor lightning	To close perforation with the help of MTA or ZOE-cements
Perforation of root wall	Failure in operation technique, using of rigid files in curved canals	To close perforation with the help of MTA
Transportation of apex	Using of rigid files in curved canals, loss of the working length	To use flex files and to create an apical stop
Canal obturation by debris	Insufficient instillation	To use more volume of solutions, endodontic needles and to return to thin files
[1]Stripping	Aggressive mechanical preparation (usually by rigid files)	To provide rational postendodontic restoration of the tooth
Creation of the ledge in canal (including zipping)	Using rigid files in curved canals, loss of working length	To eliminate the ledge using flex files or microscope
Protrusion of sealer out of the apex	Loss of working length, aggressive insertion of sealer	To supervise (if no pain)
Pain after filling the root canal system	Loss of working length and pulling out infected tissue through the apex, the protrusion of sealer out of the apex	To supervise, to give nonsteroid anti-inflammatory medicines, laser therapy
Tooth fracture	Excessive preparation, not rational postendodontic recovery	To set post and crown (if possible) or to extract tooth
Appearing or progressing of periapical lesion	Insufficient medical or mechanical treatment, loss of the working length and pulling out infected tissue through the apex	To repeat endodontic treatment

[1] Stripping is excessive widening of canal in the middle third along small curvature.

SELF-CONTROL OF TOPIC COMPREHENSION

TEST

1. **Purpose of endodontic treatment is:**
   a) sterilization of root canal system;
   b) decrease of pain;
   c) preparation of tooth for orthopedic treatment;
   d) to preserve functional value of the tooth;
   e) to fill root canals.

2. **Additional methods of examination which are used in endodontics, are:**
   a) X-ray examination;
   b) laser reflectometria;
   c) cold test;
   d) electric pulp test;
   e) spectrofotometria.

3. **Result of the electric pulp test can be misinterpreted in case of:**
   a) pulp calcification;
   b) root resorption;
   c) incomplete root formation;
   d) when anesthesia is made;
   e) excessive enamel drying.

4. **Disadvantages of a latex rubber dam application during endodontic treatment are:**
   a) loss of axial landmark at creation of endodontic access;
   b) protection of gingiva from sodium hypochlorite;
   c) possibility of gingiva's trauma;
   d) possible allergy;
   e) good isolation from saliva.

5. **For removing dentin coves the following burs can be used:**
   a) a ball-shaped bur with short neck;
   b) EndoAccess bur;
   c) a cylinder bur with a round nonactive top;
   d) any conical bur;
   e) any ball-shaped bur.

6. **For searching the canal orifice we can use:**
   a) K-file № 10;
   b) StartX № 4;
   c) Protaper F1;
   d) perioprobe;
   e) C-file № 08.

7. **Proper assessment of the root canal working length is possible:**
   a) only by X-ray examination;
   b) by combination of manual method and X-ray examination;
   c) by subsequent usage of the apex locator and X-ray examination;
   d) only by usage of the apex locator;
   e) only by manual method.

8. **The working length is set after apexlocation if at X-ray film:**
   a) the file doesn't reach X-ray top 1.5 mm and the farther root canal isn't visible;
   b) the file doesn't reach X-ray top 1.0 mm and the farther root canal isn't visible;
   c) the file doesn't reach X-ray top 1.5 mm and the root canal is visible by 1.0 mm farther;
   d) the file doesn't reach X-ray top 2.0 mm and the root canal is visible by 1.5 mm farther;
   e) the file doesn't reach X-ray top 3.5 mm and the root canal is visible by 2.0 mm farther.

9. **To decrease the root canal angle the effort during mechanical preparation must be directed:**
   a) at small canal curvature;
   b) mesially;
   c) at furcation area;
   d) at large curvature of the canal;
   e) distally.

10. **The basic rules of medical and mechanical preparation of root canals are:**
   a) usage of 3 ml of sodium hypochlorite for 1 canal;
   b) one time usage of small size tools;
   c) frequent canal instillation by sodium hypochlorite;
   d) visual checking of small size files before their second time usage;
   e) not to use files with visual features of fatigue.

11. **Sodium hypochlorite has proteolytic properties in concentration:**
   a) over 0.5 %;
   b) over 1 %;
   c) to 3 %;
   d) to 5 %;
   e) more than 3 %.

12. **Disadvantages of coronal preparation concept are:**
   a) significant preparation of apical third of canal;
   b) difficulties of application in curved canals;
   c) special more expensive files are preferable;
   d) poor condition for irrigation;
   e) risk of incomplete preparation of the apical third of canal.

13. System Protaper has the following characteristics:
a) preparation from apex to crown («step back»);
b) creation of good conditions for irrigation;
c) is available only in machine version;
d) preparation from the crown to apex («crown down»);
e) permanent conicity of files.

14. Properties of EDTA:
a) removal of smear layer;
b) softening of dentin;
c) antibacterial;
d) bleaching;
e) proteolytic.

15. For endodontic treatment the concentration of EDTA is applied as follows:
a) 0.5–5.25 %;
b) 0.2–20 %;
c) 15–19 %;
d) 5 %;
e) 3 %.

16. The medicines for temporary filling of root canals, containing calcium hydroxide and iodoform, are:
a) «Calxyl» («OCO»);
b) «Calcicur» («Voco»);
c) «Metapasta» («Meta»);
d) «Metapex» («Meta»);
e) «Apexdent» («VladMiVa»).

17. The medicines for temporary filling of root canals, containing only calcium hydroxide as active substance, are:
a) «Calxyl» («OCO»);
b) «Calcicur» («Voco»);
c) «Metapasta» («Meta»);
d) «Metapex» («Meta»);
e) «Apexdent» («VladMiVa»).

18. The methods of obturation of root canals by cold gutta-percha are:
a) lateral condensation;
b) vertical condensation;
c) GuttaCore;
d) gutta-percha injection;
e) thermomechanical condensation.

19. The methods of obturation of root canals by thermoplastified gutta-percha are:

a) lateral condensation;
b) vertical condensation;
c) GuttaCore;
d) gutta-percha injection;
e) thermomechanical condensation.

20. Time of MTA hardening is:

a) 24 hours;
b) 5–7 minutes;
c) 2.45–4 hours;
d) 2–3 days;
e) 1 hour.

21. Indications for MTA usage are:

a) indirect and direct pulp covering;
b) only direct pulp covering;
c) apexogenesis and apexification;
d) retrograde filling;
e) perforation closure.

22. Advantages of resin-based sealers are:

a) biocompatibility;
b) high viscosity;
c) low viscosity;
d) low sensibility to humidity;
e) active stimulation of tissue regeneration.

23. Advantages of MTA-based sealers are:

a) biocompatibility;
b) high viscosity;
c) low viscosity;
d) low sensibility to humidity;
e) stimulation of bone regeneration.

24. Criteria of successful endodontic treatment:

a) disappearing of pain;
b) closing of fistula;
c) preservation of pain;
d) sufficient condition of restoration;
e) gentle usage of tooth during chewing.

25. Reasons of sealer outcome are:

a) aggressive insert of the sealer;
b) insufficient instillation;
c) loss of working length;

d) verification of working length;
e) file fatigue.

26. Reasonsof long-lasting pain after endodontic treatment are:
a) loss of working length;
b) pulling out infected tissue out of the apex;
c) instillation by sodium hypochlorite;
d) outcome of the sealer;
e) file fatigue.

27. Treatment strategies in case of root canal obturation by dentin plugs is the combination of:
a) plentiful instillation and usage of Protapers;
b) filling at decreased working length and dynamic observation;
c) using of thin K-files and Protapers;
d) plentiful instillation and using of thin K-files;
e) plentiful instillation and MTA obturation.

28. Universal material for closing perforations of pulp cavity floor and root canals is:
a) «Endoseal»;
b) «ProRoot MTA»;
c) «Calxyl»;
d) «Dycal»;
e) «Biocept C».

29. Reasons of perforation of pulp chamber floor are:
a) lack of knowledge about pulp cavity topography;
b) using of StartX;
c) poor endodontic access;
d) poor lightning;
e) using big size files in mesial canals of lower molars.

30. X-ray control after tooth treatment without periapical changes are made:
a) once a year during 3–4 years;
b) twice a year during 3–4 years;
c) once in 3 years;
d) according to the doctor's preference;
e) once in 5 years.

KEYS TO TEST FOR SELF-CONTROL

1 — d. **2** — a, c, d. **3** — a, b, c, d. **4** — a, c, d. **5** — b, c. **6** — a, e. **7** — c. **8** — a, b. **9** — d. **10** — b, c, e. **11** — b. **12** — c. **13** — b, d. **14** — a, b, c. **15** — c. **16** — d. **17** — a, b, c, e. **18** — a. **19** — c, d. **20** — c. **21** — a, c, d, e. **22** — a, c. **23** — a, c, e. **24** — a, b, d. **25** — a, c. **26** — a, b, d. **27** — d. **28** — b. **29** — a, c, d. **30** — a.

СПИСОК ИСПОЛЬЗОВАННОЙ ЛИТЕРАТУРЫ

Основная

1. *Терапевтическая* стоматология : учеб. пособие для студ. 5-го курса стом. ф-та. В 2 ч. Ч. 1 / А. Г. Третьякович [и др.] ; под ред. А. Г. Третьяковича, Л. Г. Борисенко. 2-е изд. Минск : БГМУ, 2006. С. 120–151.

2. *Терапевтическая* стоматология : учеб. для студ. мед. вузов / под ред. Е. В. Боровского. Москва : Медицинское информационное агентство, 2003. С. 363–508.

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

Дополнительная

4. *Боровский, Е. В.* Эндодонтическое лечение : пособие для врачей / Е. В. Боровский, Н. С. Жохова. Москва, 1997. 64 с.

5. *Манак, Т. Н.* Методы и материалы, применяемые для защиты пульпы и стимуляции репаративного дентиногенеза / Т. Н. Манак, Т. В. Чернышева // Стоматологический журнал. 2012. № 4. С. 274–281.

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

7. *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.

8. *Трофимова, Е. К.* Еще проще! Еще быстрее! Еще качественнее! / Е. К. Трофимова // Стоматологический журнал. 2010. № 3. С. 273–275.

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

10. *Юдина, Н. А.* Современные стандарты эндодонтического лечения. Часть 1. Диагностика, планирование лечения и эндодонтическое препарирование / Н. А. Юдина // Современная стоматология. 2012. № 1. С. 5–9.

11. *Юдина, Н. А.* Современные стандарты эндодонтического лечения. Часть 2. Ирригация и обтурация корневых каналов / Н. А. Юдина // Современная стоматология. 2012. № 2. С. 12–18.

CONTENT