МИНИСТЕРСТВО ЗДРАВООХРАНЕНИЯ РЕСПУБЛИКИ БЕЛАРУСЬ
БЕЛОРУССКИЙ ГОСУДАРСТВЕННЫЙ МЕДИЦИНСКИЙ УНИВЕРСИТЕТ
КАФЕДРА ОБЩЕЙ СТОМАТОЛОГИИ

МЕТОДЫ ПРЕПАРИРОВАНИЯ ТВЕРДЫХ ТКАНЕЙ ЗУБОВ

METHODS OF PREPARATION OF HARD DENTAL TISSUE

Рекомендовано Учебно-методическим объединением
по высшему медицинскому, фармацевтическому образованию
в качестве учебно-методического пособия для студентов
учреждений высшего образования, обучающихся
по специальности 1-79 01 07 «Стоматология»

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А в т о р ы: Н. М. Полонейчик, Л. И. Палий, Т. Н. Манак, А. А. Петрук

Р е ц е н з е н т ы: д-р мед. наук, проф., зав. каф. общей стоматологии Белорусской медицинской академии последипломного образования Н. А. Юдина; каф. ортопедической стоматологии и ортодонтии с курсом детской стоматологии Белорусской медицинской академии последипломного образования

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Содержит данные о методах одонтопрепарирования, используемых в клинике терапевтической и ортопедической стоматологии. Рассматриваются общие принципы препарирования с использованием различных методов и дается их сравнительная оценка. Отдельный раздел посвящен влиянию препарирования зубов на организмы врача и пациента.

Предназначено для студентов 1–5-го курсов медицинского факультета иностранных учащихся, обучающихся на английском языке по специальности «Стоматология», врачей-интернов и клинических ординаторов.

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INTRODUCTION

Preparation is an operative method of removing the affected hard tooth tissues and preparing them for smooth introduction of a filling material or the insertion of a fixed prosthesis.

Dental preparation (odontopreparation) is one of the most labor-intensive; it requires a lot of medical art manipulation in therapeutic and prosthetic dentistry and is one of the main stages in the treatment of dental caries and orthopedic rehabilitation of patients.

The main task of preparation is to remove the affected tissues and to give the cavity or tooth the most appropriate form, ensuring a strong retention of the filling or prosthetic construction.

The development of dentistry has always been directly dependent on the means exerting the function of mechanical action on the hard tissues of teeth.

The transition from the primary removal of teeth to their treatment, outlined at the beginning of the 19th century, contributed to the development of an enamel knife ("enamel cutter") by the French dentist Delabarre in 1815, intended for the removal of carious dentine.

The design of the Singer sewing machine inspired James Morrison to create in 1870 the first dental unit with a foot-drive. However, the only improvement in tooth preparation technology for the first 40 years of the 20th century was the use of electric motors in dental units.

The key point in improving the technology of tooth preparation was an increase of rotation speed of dental instruments through the improvement of dental facilities.

Significant changes also occurred in the improvement of dental handpieces and cutting tools for dental units. Before World War II, handpieces that rotate the burs at a speed of less than 12,000 rpm were used. The introduction of handpieces that provide rotational speeds from 100,000 to 300,000 rpm made it possible to improve the technology of teeth preparation. The development of diamond in the late 1930s and carbide burs in 1947 contributed to this.

In the last quarter of the 20th century, fundamentally new devices and technologies for the preparation of teeth were proposed. The work of these new devices is based on oscillating movements of the instrument, powder-jet abrasion, laser use, chemical softening of carious dentine with its subsequent gentle excavation.

Now that dentists have a wide choice of devices for the preparation of teeth and methods for carrying out this intervention, each specialist has the opportunity to individually select the optimal method for treating a patient. However, it is difficult to navigate the choice of method for a particular type of work despite there is a wide variety of devices, materials and methods of preparation. Insufficient information in literary sources and the lack of systematization of the properties and application of various methods of preparation necessitated the presentation of the material in a special manual.

The material of the educational-methodical manual corresponds to the curriculum and can be used not only by students of the dental faculty, but also by interns, clinical interns and dentists.

GENERAL CHARACTERISTICS OF TOOTH PREPARATION METHODS

Methods of odontopreparation can be classified by taking into account the principles underlying the mechanism of tooth tissue removal (Fig. 1).

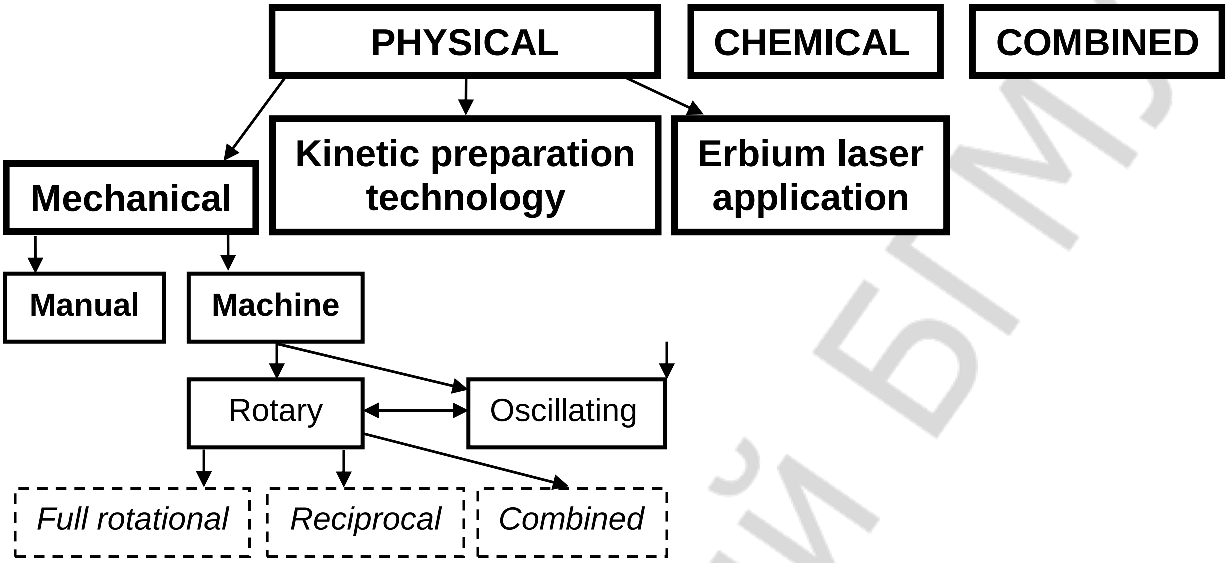


Figure 1. Classification of methods of odontopreparation, depending on the principles underlying the mechanism of tooth tissue removal

PHYSICAL METHODS OF TEETH PREPARATION

In dental practice, the methods of mechanical excision, powder-jet abrasion (kinetic preparation technology) and hydrokinetics (removal of biocalcified tooth tissue by optimized absorption of erbium laser energy by sprayed particles of water) are most widely used for the rapid removal of hard dental tissues.

MECHANICAL METHODS OF TEETH PREPARATION

Mechanical methods for the preparation of teeth include the removal of hard tissues by excision (scraping, cutting, drilling) using manual and machine methods.

MANUAL PREPARATION

Manual preparation of teeth involves the use of special cutting tools: excavators, enamel knives, separation strips, etc. In the behavior of endodontic treatment, the methods of manual preparation with the use of special tools are widely used to treat the root canal.

Excavators are double-sided tools with a working part of various sizes, which can be in the form of a blade, be round or oval (Fig. 2).

Excavators are used to remove necrotic (destructive) tooth tissues — softened dentine (Fig. 2, *c*). A special role is played by the use of an excavator in case of necrotomy in the immediate vicinity of the pulp, when there is a risk of perforation of the pulp chamber.

Excavators are selected in accordance with the size of the carious cavity. Dentine excision is performed effortlessly with intermittent, gliding, horizontal movements. The preparation begins from the more infected area, the enamel-dentine border, the instrument gradually advances towards the bottom of the carious cavity. A visual control using a dental mirror is performed.

After gentle preparation of hard tissues of the multi-surface cavity of the chewing tooth, enamel areas are often located on the distal surface and on the approximate-cervical shoulder, which cannot be removed with a rotating tool without damaging the adjacent teeth. In this case a hand tool called enamel knife is used.

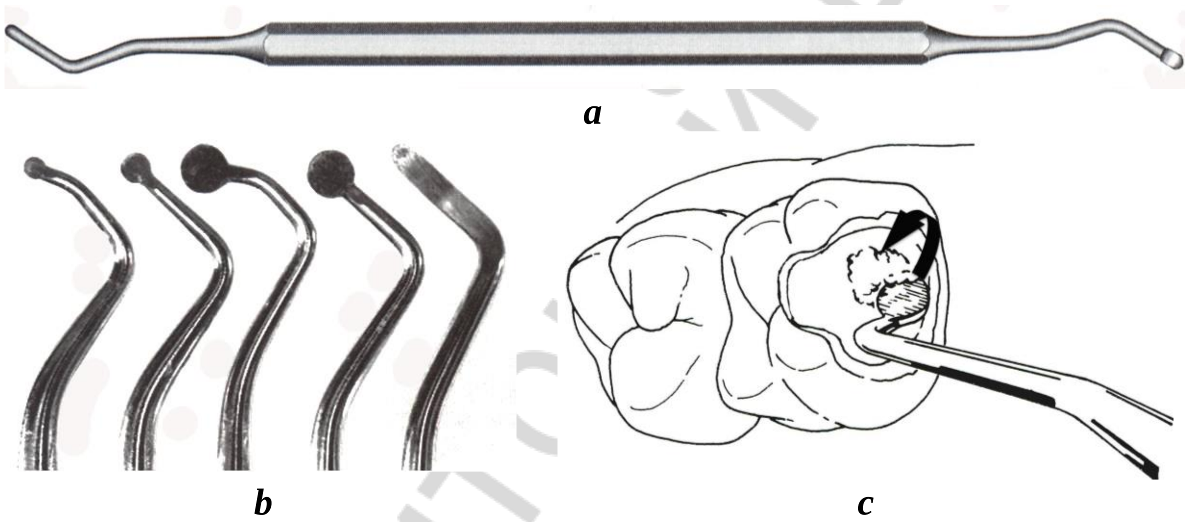


Figure. 2. Dental excavator (*a*), types of working parts (*b*) and use of an excavator for necrotomy (*c*) (modification of figure from the book. Baum L., Phillips R., Lund M. “Textbook of operative dentistry”, 1981)

The components of the enamel knife are: a faceted handle, a neck and the cutting element. The neck (the transition between the handle and the cutting element) can have from two to three bends (Fig. 3). The cutting element of the enamel knife can be small and large, flat or curved.

A curved enamel knife is also called by some authors a gingival edge (marginal) trimmer (Fig. 4). In the direction of the bends the single-plane and two-plane tools are distinguished.

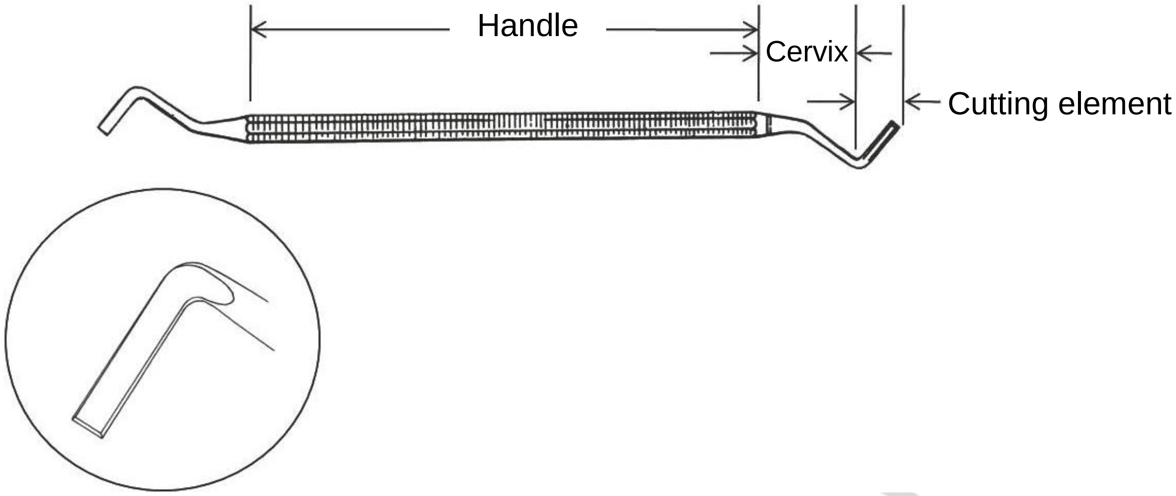


Figure. 3. Components of enamel knife

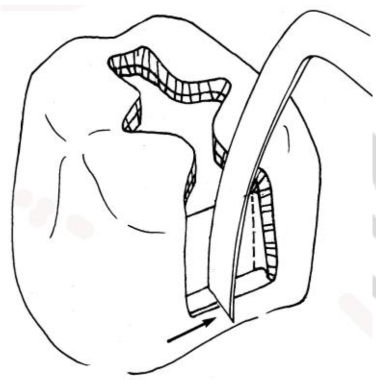
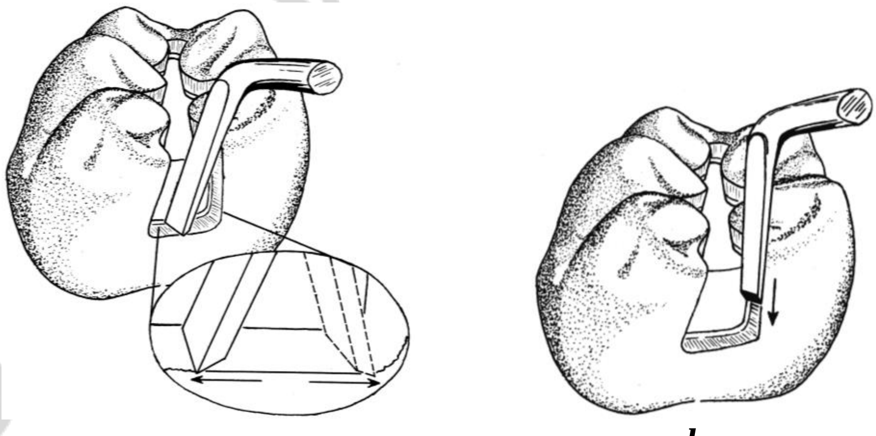


Figure 4. Gingival Edge (Marginal) Trimmer

Enamel knives are atraumatic with respect to adjacent teeth, especially when preparing the gingival site (Fig. 5, *a*) and smoothing the vertical wall of the cavity (Fig. 5, *b*) located on the approximate surface. The same tools can be used to finish the edges of a pre-deflected carious cavity.



a ***b***

Figure 5. Using the enamel knife to form the gingival area on the approximal tooth surface (*a*) and to smooth the vertical cavity wall (*b*) (a modification of the picture from the book. Baum L., Phillips R., Lund M. "Textbook of operative dentistry", 1981)

The use of hand tools allows you to achieve optimal results of work and provides ergonomic preparation.

The hand tool has a number of advantages. The main one is the possibility of tactile perception. When using hand tools with sharp blades, it is possible to determine the degree of smoothness by its tactile sensations — the roughness of the tooth surface, which cannot be done by other types of preparation.

When removing large parts of the enamel knife, it is clamped in the hand, while leaning with the thumb on the sick or adjacent tooth (Fig. 6, *a*, *b*). Such use of an enamel knife, excludes the possibility of its slipping and injury of the surrounding soft tissue.

a

b

Figure 6. Enamel knives: straight (*a*) and with the angular position of the working part (*b*)

When removing small layers of enamel, it is recommended to keep the enamel knife "in the position of a writing pen". The control of the tool is secured by the thumb and forefinger. The middle finger in contact with the neck of the instrument gives both stability and driving force. In some situations, for additional support, the fingers of the left hand are used, which are fixed by the thumb and forefinger of the neck of the instruments, providing support and control. When working on the teeth of the upper jaw, the turns of the fingers, palms and wrists are added to this method of holding the instrument.

Indications for manual preparation using excavators and enamel knives:

- children and elderly people;
- patients haring contraindications for machine preparation: severe cardiovascular diseases, post-infarction condition, nervous system diseases with increased excitability, bedridden patients, disabled people, pregnant women, patients with increased individual sensitivity to anesthetics or having contraindications for their application;
- patients with irresistible fear, categorical rejection of machine preparation at any age,
- preparation using the method of atraumatic restoration equipment (ART);

However, working with hand tools is labor- and time consuming.

In a number of clinical situations, when sparing separation of the approximate surfaces of the teeth is required, metal separation strips are used as tools for manual preparation (Fig. 7). Metal separation strips are one-side coated with diamond abrasive material. The strips are produced with a length of

147–150 mm, a width of 3.75 and 2.5 mm and have a thickness of from 0.08 to 0.13 mm. In the center of the gloss there is a space free from abrasive (from 16 to 40 mm). Diamond grains of medium (107–127 µm), fine (40–45 µm) or very fine grain (20–25 µm) are used as an abrasive coating. The separation plate is inserted into the interdental space free of abrasive, its ends are fixed with the thumb and index fingers of the hands and with the help of reciprocating movements to apply pressure to the processed tooth, its approximate surface is separated.

Figure 7. Metal separation strips

Manual preparation methods are widely used for root canal treatment during endodontic treatment. For this purpose, special endodontic instruments: root rasps, K-formers, K-files, H-files, root canal dilators and other modifications are used.

The root rasp (ratail-file, rasp) is used mainly for expanding the root canal by scraping its walls during vertical reciprocating movements. It has about 50 teeth of 1/3 wire diameter, located at right angles to the tool axis (Fig. 8, *a*).

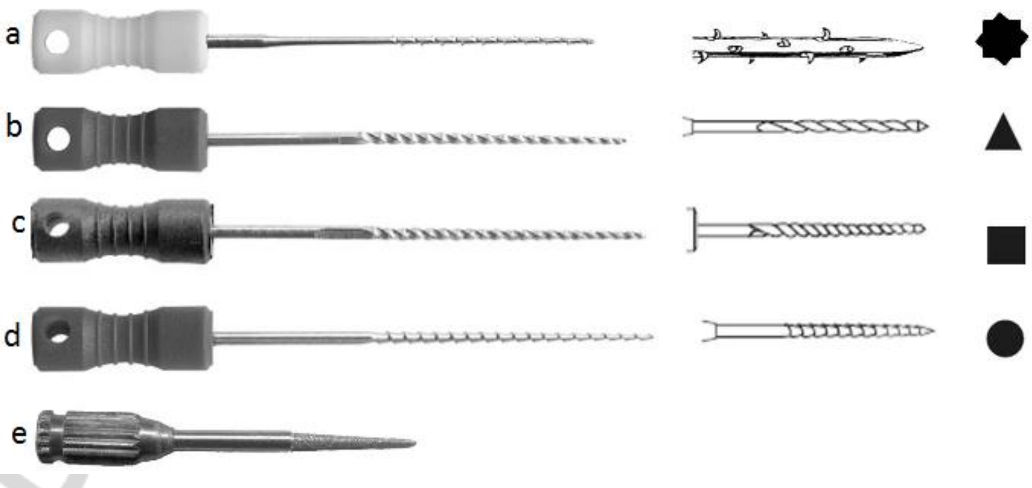


Figure 8. Some types of manual endodontic instruments for the passage and extension of root canals:
a — root rapil; *b* — K-reamer; *c* — K-file; *d* — H-file; *e* — dilator of the mouth of the root canal

K-type (K is the initial letter of the name of the first manufacturer of this type of tool — Kerr) includes tools manufactured by twisting a work piece of a certain cross section (metal fibers are not damaged when twisting, which contributes to maintaining bending strength). The cross section is usually triangular or square. The most common section of tools up to size 25 is square, 30–140 sizes are triangular (to prevent excessive rigidity, elasticity and increase cutting ability). The angle at the top for standard tools is 75°.

K-reamer is a tool having an angle of 20° between the cutting edge and the longitudinal axis. The number of cutting planes (coils) is from 10.5 to 16 for small sizes, up to 5 — for large ones. Work stages: introduction (penetration), rotation, elimination (retraction, during which the cutting ability of the tool is realized). Rotation is allowed to no more than $^1/_4$–$^1/_2$ turn clockwise; in narrow or curved canals and for reamers of large sizes — to $^1/_4$ (Fig. 8, *b*).

K-file is a tool with an angle of 25–40° between the cutting edge and the longitudinal axis (Fig. 8, *c*). The number of cutting planes (turns) is larger than that of K-reamer, from 33 for small sizes to 8 for large ones (1.5–2.5 turns per mm), therefore their cutting ability exceeds that of K-formers. In the canal, the tool should move predominantly in the vertical direction (up and down). Rotational movement is allowed up to 450 rpm clockwise and counterclockwise.

The H-type of tools (H is the initial letter of the name of the first manufacturer Hedstroem) refers to the H-file. The tool is made by milling from a billet of round steel wire (Fig. 8, *d*). This instrument has a maximum angle between the cutting edge and the longitudinal axis — 60–65°, as well as the largest number of cutting planes — from 31 to 14. This causes a higher cutting ability than K-tools. Movements in the canal are vertical, sawing, scraping. The cutting capacity is realized at the exit of the canal.

The root canal dilator is a hand-held tool with diamond spraying of the working part (Fig. 8, *e*) or with a uniformly shrinking faceted working part which is used in straight canal sections in the rotational mode.

MACHINE PREPARATION

When creating the necessary cavity shape for the restoration of various filling materials or the stump of the tooth crown in the manufacture of orthopedic structures, as well as during endodontic treatment, most often the preparation of teeth is carried out by using rotary or oscillating systems that are included in most universal dental instruments or produced as additional nodes.

Rotary machine preparation

The rotation system includes a metal or abrasive tool and a dental handpiece (a device designed to transmit a rotational motion to the tool). All variety of dental handpieces can be divided into two groups: turbine and micromotor.

In turbine handpieces (Fig. 9, *a*), for rotation of bur, compressed air is used, which rotates the rotor (Fig. 9, *b*), located directly in the handpiece head. The main feature of turbine handpieces is to provide high tool rotation speeds (over 250.000 rpm).

To get a lower speed micromotor handpieces are usually used.

a ***b***

Figure 9. Turbine (*a*) and rotor (*b*) dental handpiece

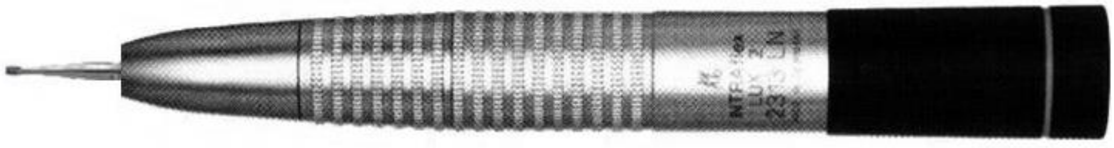
In micromotor handpieces, the rotational movement of bur is achieved by using a complex system of gearboxes, shafts and transmission gears that transform the movement of the shaft of an electric or pneumatic motor (Fig. 10).

Figure 10. Diagram of a micromotor dental angular handpiece with a system of reductors, shafts and gears

The motor handpiece is mounted on an electric or pneumatic (air) micromotor, by which it is driven (Fig. 11).

Figure 11. Pneumatic (air) micromotor

Along with a three-component rotational system, there is a so-called two-component version of the system (Fig. 12), in which the handpiece is integrated with an air micromotor joined with a multiflex joint used for turbine handpieces (INTRAflex LUX motor, KaVo, Germany).



a ***b***

Figure 12. Two-component rotational system:
a — metal blade or abrasive tool; *b* — dental straight handpiece with a built-in micromotor

Micromotor handpieces, as compared with turbine once, provide greater power when cutting with the tool surface.

In addition, micromotor handpieces, unlike turbine, allow you to adjust the speed of rotation of bur without reducing power.

There are the following types of conversion speed of rotation micromotor handpieces:

- transfer of rotation without changing the speed (handpieces with blue color marks);
- transfer of rotation with decreasing speed (reducing handpieces with green color marking);
- transfer of rotation with increasing speed (raising handpieces with red color marking).

Depending on the design features, micromotor handpieces are produced in the form of angular (the tool axis is at an angle to the main handpiece axis) and straight lines (the tool axis coincides with the main handpiece axis) (Fig. 13).

a ***b***

Figure 13. Types of micromotor dental handpieces:
a — angular; *b* — straight

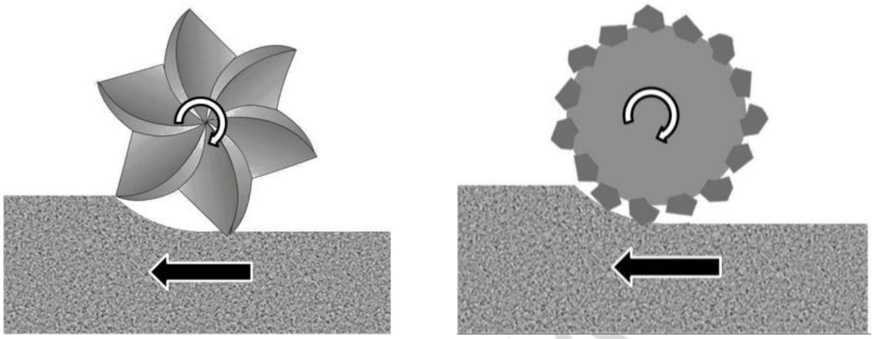
Machine preparation using angular handpieces, in turn, is divided into full rotation (360 degrees) and reciprocal (from the Latin. Reciprocus — returning, mutually alternating). Fig. 14 presents handpieces with a full (Fig. 14, *a*) and reciprocal rotation of the instrument around its longitudinal axis (Fig. 14, *b*).

During reciprocal rotation, the instrument performs reciprocating movements clockwise and counterclockwise in limits up to 90 degrees.

a ***b***

Figure 14. Types of angular micromotor handpieces:
a — full-rotation; *b* — reciprocal

The cutting (scraping) effect of full-rotation machine tools is due to the contact of metal blades or grains of abrasive material with the surface to be treated (Fig. 15).



a ***b***

Figure 15. The principle of the cutting (scraping) action of metal blade (*a*) and abrasive (*b*) rotary tools

Rotary instruments include:

- metal tools made from metal alloys, the working part of which has a number of notches in the form of blades, special cutting or other structural features (steel and hard-alloy burs, mills, drills, endodontic tools, etc.);
- abrasive tools obtained from grains of abrasive materials interconnected by bonding materials (heads, discs, circles, etc.);
- special devices for professional hygiene, grinding and polishing (brushes, felt, etc.).

Depending on the cleanliness of the surface created by the preparation of hard dental tissues, rotary instruments are selected to ensure the creation of the initial classes surface cleanliness (grinding) and high classes surface cleanliness (finishing, polishing).

The quality of treatment and the elimination of the development of possible complications depends on the adequate use of rotary instruments during each specific stage of treatment.

When choosing a tool, the following parameters should be taken into account:

- hardness of the treated tissue;

- mode of operation, taking into account the type of operational method and functional tasks;
- economic efficiency (productivity, tool life, its cost).

The effectiveness of the preparation largely depends on the hardness of the treated tissues and the hardness of the rotary instruments (materials used for their manufacture). Table 1 shows the indicators of hardness of dental tissues and some types of materials used for the preparation of rotary instruments.

Table 1

Characteristics of tooth hardness and rotary instruments (Ivanov A. A., Poloneychik N. M., 1999)

Dissected tissues	Hardness, MPa	Instruments (abrasive materials)	Hardness, MPa
Tooth enamel	3000–4250	Steel burs (X46CrS13)	8000
Dentinee	600–800	Carbide burs	28 000
Root cement	450–550	Diamond synthetic burs*	53 000–96 000

* The hardness of an instrument made of an abrasive material does not match the hardness of the abrasive, because depends on the strength of the bundle of grains in the technology of manufacturing tools.

Recommendations on the use of dental rotating tools, depending on the material being processed are presented in Table 2.

Table 2

Application of dental rotary instruments depending on the processed material (GEBR. BRASS. GmbH & Co., 1989)

Processed material	Tool (working part material)		
	metal paddle		abrasive
	stainless steel (X46CrS13)	carbide (tungsten carbide)	diamond
Tooth enamel	Unsuitable	fit	**recommended**
Dentinee	Fit	**recommended**	fit
Root cement	**Recommended**	fit	fit

As it can be seen from the table, solid-alloy and diamond rotating tools have a certain universality. At the same time, it is necessary to take into account the ability of hard tooth tissues to “salt” the working surface of the instrument, for example, when processing dentinee or cement with diamond heads.

The mode of operation with rotary instruments includes the speed of rotation of the instrument, the pressure exerted on the prepared tissues and the cooling method used in the process.

The choice of preparation speed depends on the type of hard tissue being prepared, functional tasks and the tools used. For each cavity preparation stage, different tools with different speeds are used, respecting the maximum number of revolutions established for each type of rotary tool. The operator must constantly remember that with a high rotational speed and strong pressure, a significant amount of heat is released, which can adversely affect the live pulp.

A distinction is made between ultrahigh (120.000–400.000 rpm), high (20.000–45.000 rpm), medium (4.500–45.000 rpm) and low (500–4.500 rpm) speed rotary tools. If the initial preparation of the cavity walls in the area of the tooth enamel is performed in the high and ultrahigh speed ranges, then the excavation and finishing of the edges of the enamel is in the low and middle ranges. When using metal blade and abrasive tools for preparing teeth (carbide burs and diamond heads), it is recommended to use the rotation speeds of the tools presented in Table 3.

Table 3

The speed of rotation of carbide burs and diamond heads, depending on the functional task (Arutyunov S. D. et al., 2007)

Functional task	Rotation speed (rpm)
Disclosure of carious cavity	200 000–250 000
Diamond head finishing	120 000–170 000
Dissection of dentine removed from the pulp	40 000
Carbide finishing	10 000
Removal of carious dentine	2000
Dental dissection in the area around the pulp	1500

The use of dental instruments for the preparation of teeth should be carried out using the pressure of the instrument on the surface to be treated. The pressure must be strictly metered depending on the working conditions and tools used.

The increase in pressure leads to frictional heat, which can lead to thermal burns of the tooth pulp. Therefore, you should not use too much effort, especially with tools designed to work with turbine handpieces. Intermittent, non-forced type of work is recommended. This is critical for increasing tool life.

Table 4 shows the pressure indicators of rotating instruments on the surface to be treated (in grams), recommended considering the type of instrument, the grit size of the abrasive material and the accessory of the instrument to the dental handpiece.

Table 4

Indicators of rotating instruments pressure (in grams) on the machined surface, recommended depending on the type of handpeaces, the grain of abrasive material and the type of tool body (Hager & Meisinger GmbH)

Steel burs	Diamond heads (taking into account the abrasive grit)				Carbide burs (taking into account belonging to the factory)	
	ultra fine	small	medium large	extra large	Micromotor (straight, angular)	turbine
30–400	10–100	20–180	20–220	30–350	30–300	30–50

The kinetic energy transmitted by the instrument to the tooth causes heating of the prepared tissues. Effective cooling prevents the formation of high-temperature lesions on the treated surface. Fig. 16 shows the dependence of the temperature in the dentine of the tooth during its preparation on the duration of the operation and cooling mode. As it can be seen from the graph, the effective cooling methods are water and air-water cooling. When characterizing water cooling, it should be noted that when the instrument has a rotation speed of more than 1500 rpm, the minimum cooling water supply should be at least 50 ml/min.

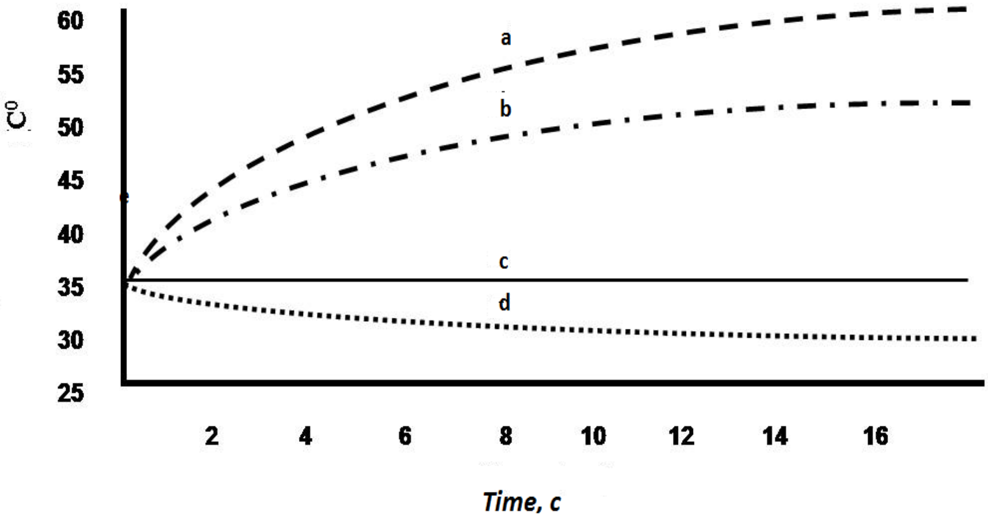


Figure 16. Dependence of temperature in the tooth dentine on the duration of the work and cooling mode during its preparation (Baum L., Phillips R., Lund M. “Textbook of operative dentistry”, 1981):
a — without cooling; *b* — with air cooling; *c* — with the use of cooling water and air turbine handpiece; *d* — using water cooling

In dental practice, the preparation process is associated with the processing of complex surfaces and the solution of various functional tasks (cutting, drilling, grinding, polishing, etc.). The result of the preparation of teeth depends largely on the compliance of the selection of the rotary instrument to the stage of preparation, which must be carried out in the process of work. The choice of instrument is often determined by the professional experience of the doctor, their attitude and, to a certain extent, the prejudice to the instrument that has been developed in the course of clinical activity.

At the same time, especially at the initial stage of professional activity, recommendations should be used on the functional purpose of each instrument, taking into account the material, shape and size of its working part for each surgical intervention. Some examples of the use of dental cutting rotary tools for performing various functional tasks, taking into account the shape of the working part of the tool, are presented in Fig. 17.

Spherical carbide burs (Fig. 17, *a*) are used in the preparation of enamel and dentine. Diamond spherical heads are used for opening and widening of the carious cavity and correction of the occlusal surface. Burs with a cylindrical shape of the working surface (Fig. 17, *b*, *c*) are used to open the cavity along the fissures, remove the overhanging edges of the cavity, form a flat bottom, cervical step and occlusal ledge. When working in the field of enamel, diamond heads and hard-alloye burs are used, and in the area of dentine, steel and carbide burs are used.

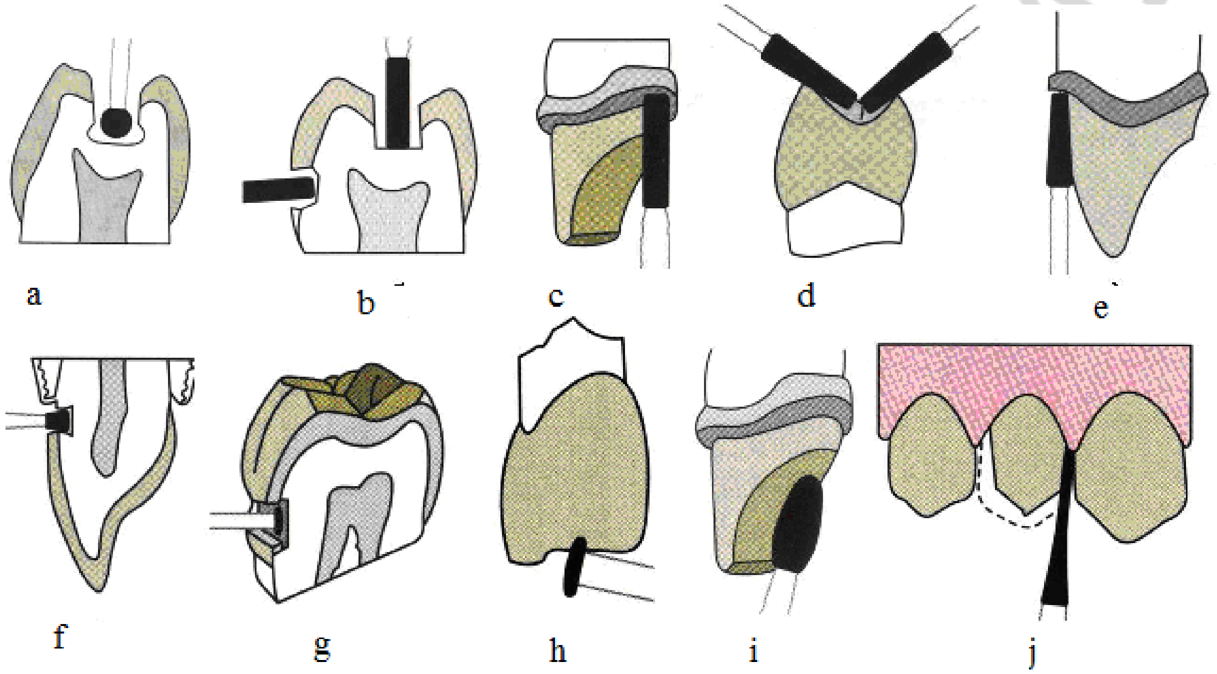


Figure 17. Examples of the use of rotary tools for the preparation of teeth:
a — spherical shape; *b*, *c* — cylindrical shape; *d*, *e* — conical shape; *f* — a reverse cone;
g, *h* — wheel bur; *i* — bud-shaped (oval, reniform) head; *j* — needle-shaped (bayonet) head

Burs with a conical working surface (Fig. 17, *d*, *e*) are used to prepare the occlusal surface under an artificial crown, open the cavity along the fissures, form diverging walls of the cavity, and cervical step, impart taper to the tooth when it is prepared under artificial crown.

Tools with a working surface made in the form of an inverted cone (reverse cone) are used to create retention points, dissect the occlusal surface, contour the walls of the teeth after preparation (Fig. 17, *f*).

The wheel bur (Fig. 17, *g*, *h*) is used for cutting stamped crowns and for preparing class V cavities in order to create retention points. Diamond wheel heads are used to prepare the occlusal surface and the cutting edge of the tooth.

The bud-shaped (oval, reniform) head (Fig. 17, *i*) is used for the preparation of occlusal surfaces, the treatment of palatal and lingual surfaces of teeth.

The needle-shaped (bayonet) head (Fig. 17, *j*) is used to separate the approximate surfaces of the teeth, create enamel bevels, and prepare hard tooth tissues in the subgingival area.

To minimize the traumatic impact of burs on tooth tissue during the preparation of cavities and the formation of an optimal microrelief of a tooth stump, it is necessary to use burs of various abrasivity in a certain sequence.

At the first stage of odontopreparation, tools with a large size of abrasive granules (super coarse grit, 151–180 μm, black marking) are usually used. In the future, the necessary shape of the cavity or tooth stump is specified with the help of diamond tools of large (126–150 micron, green marking) or medium (91–125 micron, blue marking) grit. The final preparation is carried out using tools with a small grain size of the abrasive (40–76 microns, red marking).

When choosing a rotary instrument, its economic efficiency is taken into account. Under the economic efficiency of the tool its performance, durability and cost are meant.

The performance of a dental rotating instrument depends on the properties of the material being processed, the properties of the cutting part of the instrument, on the cutting mode, on the design and geometrical parameters of the tool, and on cooling.

The firmness (reliability)of the tool is the time of using the tool before its wear. Wear of the tool is characterized by its mean time to failure in minutes of working (machine) time, and for steel burs is 5 minutes, diamond heads — 20 minutes, carbide burs — 50 minutes of working time.

Given the wear and tear of dental instruments, they should be replaced promptly. The poor quality of the cutting tool makes the doctor exert greater pressure on the surface to be treated, increase the speed of rotation of the drill, which leads to a thermal effect with the occurrence of high-temperature lesions.

In recent years, machine-based methods of preparation using angular handpieces, which provide reciprocal (returning, mutually alternating) rotation of the instrument around its longitudinal axis has widely been used in the dental clinic. In reciprocal rotation, the tool reciprocates clockwise and counterclockwise up to 90 degrees.

The reciprocal rotation of the instruments is used to prepare the root canal during endodontic treatment. An endodontic instrument installed in a dental corner (machine with a case diameter of 2.35 mm or hand-held with a handle diameter from 3.5 to 4 mm) does not perform a full free turn, but rotates only 900 rpm ($^{1}/_{4}$ turn clockwise and counterclockwise) around the axis of the body (Fig. 18).

For the separation of teeth, KaVo O-drive OD30 reciprocating handpieces (Germany) with diamond segmental separating discs with a radius of 14 mm and thickness from 0.15 to 0.45 mm have found a wide application. In the course of work, the working part of the tool performs reciprocating movements within

30 degrees around the longitudinal axis of the corpus and provides high efficiency grinding of the approximate tooth surfaces (Fig. 19).

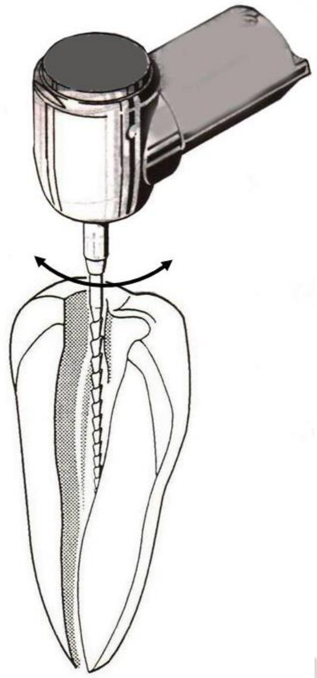


Figure 18. Angular dental handpiece for root canal preparation for endodontic treatment using reciprocal tool rotations

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

Figure 19. Angular dental handpiece for the separation of teeth using reciprocal rotations (*a*), separation reciprocating disk (*b*) and the scheme of tools work (*c*)

OSCILLATING MACHINE PREPARATION

Some dental angled micromotor handpieces allow you to convert the type of movement of the instrument. Rotation is converted into cyclically repetitive oscillatory motion. This type of tool making oscillatory movements, is called oscillating (from the Latin “oscillo” — swing).

During the reciprocating movement of the instrument along its longitudinal axis within 0.4 mm, the walls of the root canal expand and level (Fig. 20). For these purposes, manual (core diameter 2.35 mm) and machine endodontic instruments (handle diameter from 3.5 to 4 mm) are used.

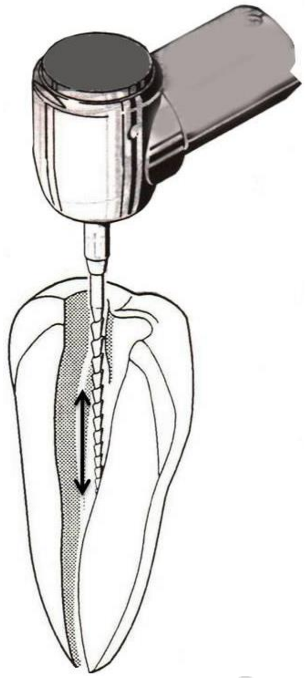


Figure 20. Angular dental handpiece for endodontic treatment using oscillating movements of the instrument while expanding and leveling the walls of the root canal

Dissection of hard tooth tissues in the approximate or subgingival area with rotational instruments is considerably difficult. The use of oscillating tools greatly simplifies this task. Special files (files “Profin Lamineer”, “Intensiv”, etc.) intended for fixing in angular dental handpieces with special heads (EVA-system, etc.) provide grinding and finishing with oscillating movements of the instrument with a move from 0.4 to 1.5 mm. Tools with diamond grit from 15 to 125 microns are used to perform tooth separation (Fig. 21, *a*), mowing the ledge and the edges of cavities (Fig. 21, *b*), removing excess bonding after cementing to the lingual (Fig. 21, *c*) and approximate (Fig. 21, *d*, *e*) surfaces, grinding the root surface in the subgingival part of the tooth (Fig. 21, *e*) and in other clinical situations. Since the diamond coating is applied only to one side of the nail files, the tooth next to it is not damaged during the preparation process.

Oscillating movements of instruments can be provided with air and piezoelectric scalers that create oscillations with sound (air — 7000 Hz) and ultrasonic frequency (piezoelectric — up to 35000 Hz).

In air scalers for tooth preparation, nozzles are used, which are diamond files with abrasive grit from 25 to 46 microns of various shapes and sizes to perform different types of work (Fig. 22).

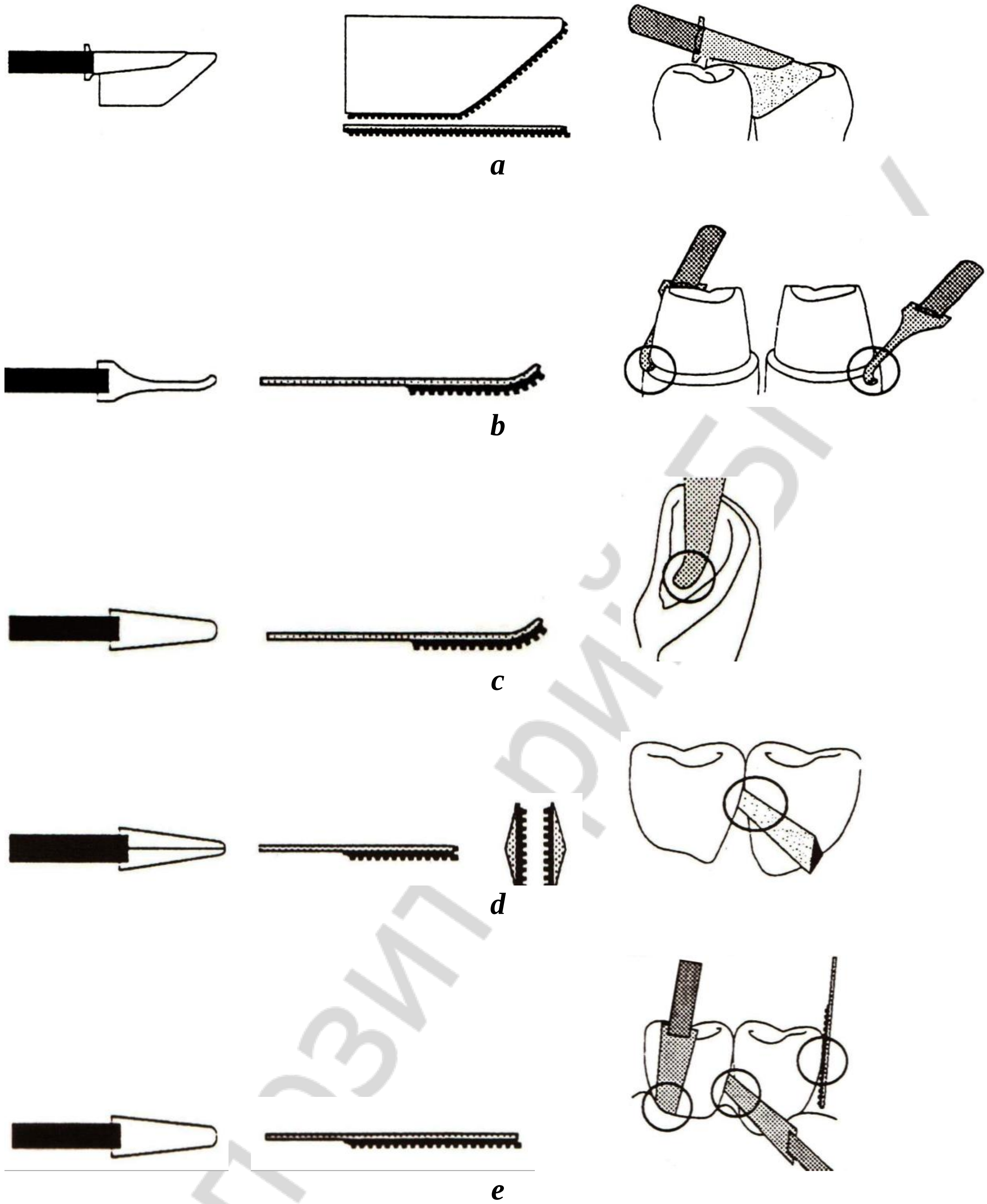


Figure 21. Special files intended for fixing in angular dental handpieces with special heads, providing grinding and finishing with oscillating movements of the instrument

Figure 22. Sonicflex Line air scaler from KaVo (Germany) with diamond nozzles for tooth preparation

Dissection of teeth with diamond tools with oscillating movements makes it easy to treat a carious cavity (Fig. 23, *a*, *b*). Nados have diamond spraying only on the working surface, which allows for accurate preparation and processing of the edges of the enamel cavity (Fig. 23, *c*) without disturbing the tissues of the approximate surface of the adjacent tooth (Fig. 23, *d*). Special angular handpieces make it possible to prepare an approximate surface without removing the cavity on the chewing surface (Fig. 23, *e*). During the reciprocating movement of the tool, the extension and alignment of the mouth walls of the root canal of the tooth is possible (Fig. 23, *f*).

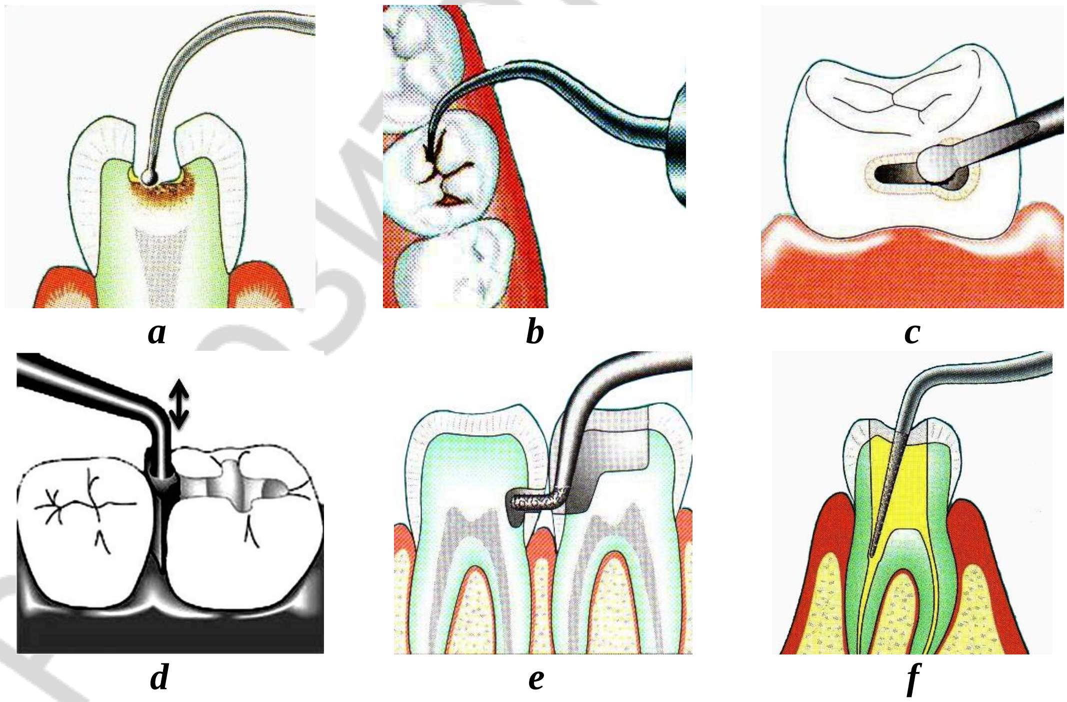


Figure 23. Examples of teeth preparation using the oscillating instruments of the air scaler Sonicflex Line

Oscillating movements of air scalers' instruments with a sound frequency (7000 Hz) create an amplitude of displacement of the head (range of motion) in the range from 120 to 240 microns, which ensures high efficiency of preparation.

The working pressure on the prepared tissues of the oscillating handpiece with a diamond nozzle is much less than when the tooth is treated with rotating instruments. Heat generation, and, therefore, heating of the tooth with oscillating preparation is negligible.

Oscillating preparation of teeth using the Vector ultrasound system (Dürr Dental, Germany) is carried out with special setups without coating them with abrasive material. The scraping action is provided by applying an abrasive liquid with aluminum oxide to the oscillating handpiece (Fig. 24).

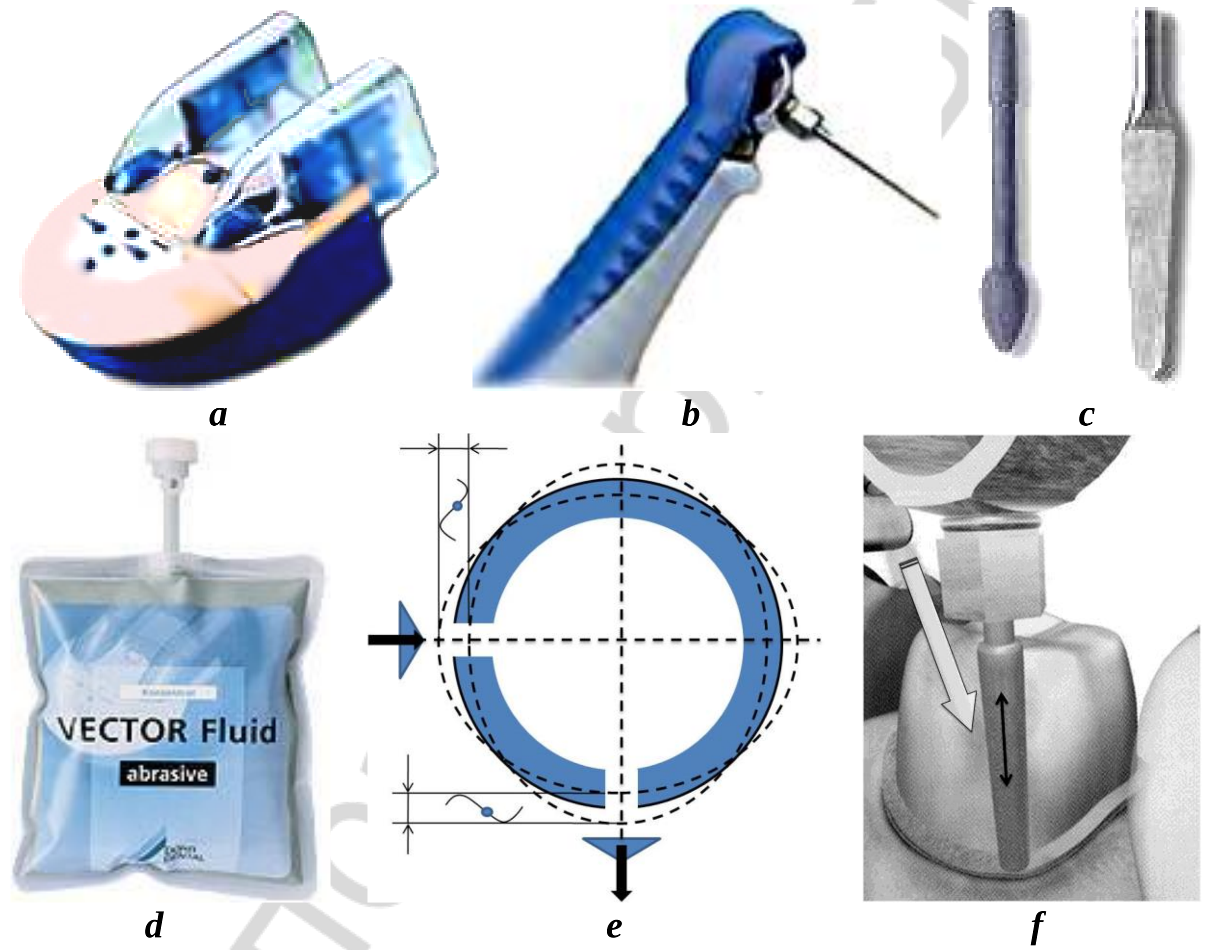


Figure 24. Vector ultrasound system (Dürr Dental, Germany):
a — base unit; *b* — oscillating handpiece; *c* — oscillating handpieces Tool Kit Prep; *d* — abrasive liquid; *e* — a scheme for converting ultrasonic dynamics (horizontal arrow) into oscillating movements of the nozzle (vertical arrow); *f* — the principle of operation of the apparatus with oscillating movements of the nozzle and the flow of the abrasive fluid to the operating field

The Vector system transforms the ultrasonic dynamics of 25,000 Hz in such a way that the dentist can work completely without causing traumas to hard tissues, fast and effectively. At present, it is proved that, when treating carious cavities with oscillating tools, only softened demineralized (carious) enamel and dentine are removed and healthy tooth tissues are not affected, which in turn determines the principle of biological expediency in dentistry.

Machine scalers can widely replace hand-held tools that are difficult for a doctor to use, and, compared to manual work, save time in their use, as well as provide painless procedures for the patient.

TECHNOLOGY OF KINETIC PREPARATION
(preparation of teeth using powder-jet abrasion, microaeroabrasion)

The development and introduction into clinical practice of sparing methods for the preparation of hard dental tissues are highly relevant. Special attention should be paid to the method of contactless preparation of teeth using the kinetic preparation technology (KIN — Kinetic Cavity Preparation).

For the first time, the method of contactless preparation of hard tissues of teeth was proposed by Dr. Robert Black (son of the famous founder of odontopreparation) in 1940 under the name “The method of cold preparation of enamel and high pressure air dentine”. Due to circumstances, the method was not recognized at that time. Only in 1985, Dr. Tim Reyne, who began to work with Black, developed a modern concept for the preparation of teeth using powder-jet abrasion (micro-aero-abrasion) using alpha-alumina powder with a particle size of 27.5 and 50 microns (Fig. 25).

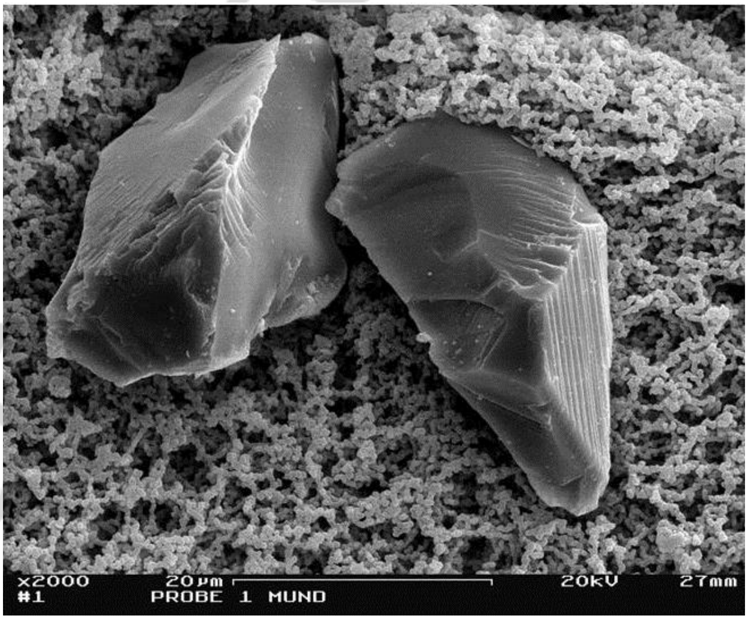


Figure 25. Grains of alpha-okid aluminum powder with a size of 27.5 microns, used for the preparation of teeth using microaerobiology technology (×2000)

The technology of kinetic preparation is used for the treatment of hard tissues and carious cavities on the principle of ultrafast ultra-disperse destruction. Under the influence of a powerful, point-focused stream of alpha alumina powder, tooth tissues are removed to the required level under eye control. Alpha-alumina is non-toxic, chemically and biologically inert, stable and neutral in color. For the technology of kinetic preparation, special equipment is used: AirFlow prep K1 (Switzerland), Repjet (USA), RONDOflex plus 360 handpiece (KaVo, Germany), etc.The handpiece of the RONDOflex plus 360 (Fig. 26, *a*) is mounted through a multiflex adapter, similar to the turbine of a universal dental unit. The principle of operation consists of a directional flow through the handpiece of a jet stream of an aerosol containing water and abrasive agents directly onto the preparation site from a distance of 1 mm (Fig. 26, *b*). From the oral cavity, the powder is removed with a vacuum cleaner.

a ***b***

Figure 26. Handpiece for microaerobrasion RONDOflex plus 360 (*a*) and the principle of its work (*b*)

The high power of the flow, provided by the equipment for the kinetic preparation technology, combined with the solid grain of the powder, which increases the aggressiveness of the impact, opens up new prospects for the application of the method.

Indications for the use of powder-jet abrasion:

- fissure processing before sealing;
- elimination of deep pigmentation of enamel;
- preparation of small carious lesions;
- preparation of adhesive surfaces for composite restorations;
- preparation of surfaces for fixing orthopedic structures.

Indications for the use of powder-jet abrasion:

- fissure processing before sealing;
- elimination of deep pigmentation of enamel;
- preparation of small carious lesions;
- preparation of adhesive surfaces for composite restorations;
- preparation of surfaces for fixing orthopedic structures.

The technology of kinetic preparation reduces the risk of microtraumas, chips, burns of enamel and dentine, the formation of cracks in the dentine and enamel, as well as postoperative hypersensitivity.

The use of microaeroabrasion in the treatment of teeth and sealing of fissures in children is especially important, because the painlessness of this procedure almost completely eliminates the appearance of fear in small patients.

TOOTH PREPARATION USING ERBIE LASERS

The achievements of modern science make it possible to use such high technologies in dentistry as laser tooth preparation. The use of laser in medicine began in the 60s of the last century, almost immediately after its creation.

Lasers are classified according to a number of parameters: pulse duration, discharge power, wavelength, energy penetration depth into tissues. The types of lasers used in dentistry are presented in Table 5. All of these lasers have different wavelengths and, accordingly, different properties and application features.

Table 5

Types of lasers used in dentistry

Laser	Wavelength, Hm
Neodymium (Nd:YAG)	532–1064
Helium-neon (He-Ne)	633
Diode	830–980
Goldmeic (Ho:YAG)	2100
Erbium (Er:YAG)	2780–2940
Carbon dioxide (CO_2)	9600–10600

Laser light is absorbed by a specific structural element that is part of the biological tissue. The absorbing substance is called the chromophore. They can be various pigments (melanin), blood, water, tooth tissues, etc. Each type of laser is designed for a specific chromophore, its energy is calibrated based on the absorbing properties of the chromophore, as well as taking into account the field of application. Neodymium laser is used in periodontology to work with soft tissues. Carbon dioxide laser (CDL) is widely used for invasion into soft tissues, but it is dangerous to use it for hard tissues due to overheating of hard tissues of the tooth and bone. In modern dentistry, lasers for teeth whitening are widely used. Due to the ability of CDL to work on different tissues (soft and hard) it significantly surpasses other erbium lasers.

The Kavo Key Lazer 3 erbium laser has quite wide applications in dentistry. Due to the fact that the target of the laser radiation is a water molecule, it can be used on almost all tissues of the oral cavity. The Kavo Key Lazer 3 laser consists of a base unit that generates light of a certain power and frequency (Fig. 27, *a*), a light guide, and a laser handpiece, with which the doctor directly works in the patient's oral cavity (Fig. 27, *b*).

a ***b***

Figure 27. The basic unit of the KaVo Key Lazer 3 erbium laser (*a*) and the handpiece for tooth preparation (*b*)

The action of light from an erbium laser is not a purely thermal process, it is caused by a thermomechanical effect. The wavelength of the erbium laser is 2940 Hm; this coincides with the maximum of the water absorption spectrum. The gentle effect of an erbium laser is due to the short duration of its pulses, upon absorption of which part of the water contained in the tissue undergoes an abrupt transition from a liquid to a vapor state. At the same time, due to the rapid expansion of water for a short time, a sufficiently high pressure occurs, and fragments of biotissue are ejected from the laser exposure zone due to the pressure drop.

The main feature of the system is the method of cutting tissue, which is called laser hydrokinetics. Hydrokinetics is the process of removing bio-calcified tissue by optimizing the laser energy absorption by sprayed particles of water, which leads to the fact that energy-charged microparticles acquire the ability to accurately and accurately cut tissue. Water particles are energy-charged agents that removes the target tissue (Fig. 28).

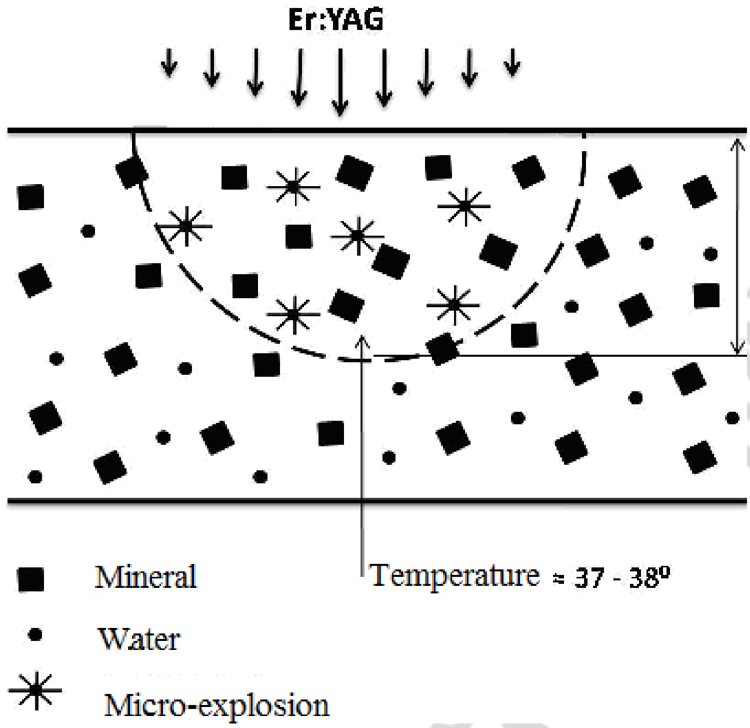


Figure 28. Scheme of the erbium laser action mechanism

During working with laser technology eye protection must be used, since Laser light is harmful to the eyes. The doctor and the patient must wear protective glasses during the preparation.

Erbium laser dissection takes place as follows: the laser operates in a pulsed mode, sending an average of about 10 beams each second. Each impulse carries a strictly specified amount of energy. The laser beam, hitting the hard tissues, uses the thinnest layer of about 0.003 mm. The micro-explosion resulting from the heating of water molecules remove particles of enamel and dentine, which are immediately removed from the cavity with a water-air spray. The procedure is absolutely painless, since there is no excessive heating of the tooth. Dissection occurs quite quickly, but the doctor is able to accurately control the process, immediately interrupting it with one movement. Easy and complete control when working with a laser ensures the highest accuracy and safety.

After laser preparation an ideal cavity is prepared for filling. The edges of the cavity walls are rounded, there is no “smeared layer”, no cracks or chips remain on the enamel, the surface is absolutely clean. In addition, the cavity after preparation with a laser remains sterile and does not require additional antiseptic treatment, since laser light destroys any pathogenic flora.

When the laser machine is operated, the patient does not hear the unpleasant noise of the drill. This psychological factor is sometimes crucial for a patient when choosing a method of treatment.

In addition, laser preparation is a non-contact procedure, i. e. none of the components of the laser system is in direct contact with biological tissues, i. e. preparation takes place remotely. After operation, only the handpiece is sterilized. It is known that when working with a turbine the prepared particles of solid tissues, together with infectious agents, are ejected into the air of the dental office with great force. This does not occur when a laser is used. With laser preparation, solid particles do not acquire high kinetic energy and are immediately deposited by a jet of water spray. This makes it possible to organize an unprecedented sanitary safety and epidemiological regime of the dental office, which allows reducing any risk of cross-infection to zero, which is especially important today.

The use of laser systems in the treatment process can still be considered as an addition to the practical work of dentists. This is primarily due to the high cost of equipment. It will probably take some time before the use of laser systems in odonto-preparation can be recognized as an alternative to the use of rotary instruments.

CHEMICAL METHODS OF TEETH PREPARATION

The chemical (chemical-mechanical) method of preparation of the teeth consists in the chemical softening of carious dentinee and its subsequent narrowing with manual tools.

In the 1930s, a 5–10 % solution of lactic acid was used to process dental tissues. A swab with acid was injected into the carious cavity for 15–20 minutes. After removing the swab from the cavity, the remaining acid was neutralized with soda solution. The softened dentine was removed with a sharp excavator. Various modifications of the method continued to be used in the following years, but did not find wide distribution.

In 1998, Medi Team AB in Sweden proposed a system for the chemical-mechanical removal of carious dentine called Carisolv.

The treatment method consists of two stages. First, a gel consisting of two components that are automatically mixed when being extruded from a syringe is introduced into the carious cavity with a special dual syringe. The first component is a viscous gel that contains 3 amino acids (glutamine, leucine and lysine) at a concentration of 0.1 M each, the red dye is erythrosine, NaCl and CMC (carboxymethylcellulose). The second component is a 0.5 % solution of sodium hypochlorite. Formed after mixing the components of N-monochloroaminoacid have been mixed, it selectively decomposes demineralized collagen in dentine for 5–15 minutes. Then, the dentist removes the softened damaged tooth tissues from the carious cavity using a special set of hand tools (Fig. 29).

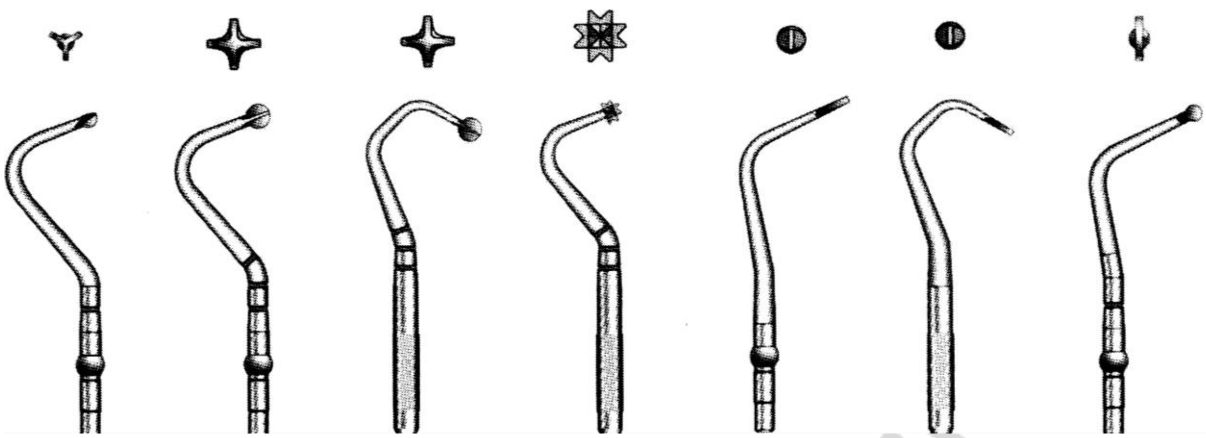


Figure 29. Work surfaces of Carisolv system tools for manual removal of carious dentine

The use of the Carisolv system provides a minimally invasive chemical-mechanical method for the treatment of caries. It can be used both for treating small carious cavities, including the roots of teeth, and for treating deep cavities. With this method of treatment, the risk of accidental opening of the pulp horn and complications after the treatment of dental caries is significantly reduced.

This method of treatment is especially suitable for young patients, who have fear of a working drill.

At present, the improvement of methods for preparing hard dental tissue continues. The main directions of this work are aimed at developing technologies that would allow:

- to ensure such distribution of mechanical energy over the treated surface, which to a greater extent depends not on the movements of the doctor’s hand, but on the density of the tissue being prepared;
- to eliminate the heating of the tooth;
- to eliminate radial beating of the tool;
- to eliminate negative emotions in patients.

EFFECTS OF PREPARATION ON THE TEETH TISSUE, ORGANISM OF THE PATIENT AND DOCTOR

The intensity of irritation of the dentine and pulp during preparation depends on the thickness of the remaining dentine, the type of rotational instrument, the speed of its rotation, the effectiveness of cooling and subsequent operations (drying, cavity processing, etc.). Exceeding the threshold of physiological irritation can lead to injury, i.e. aspiration of odontoblasts or accumulation of erythrocytes in the dentineal tubules. Aspiration of odontoblastic nuclei is a consequence of the movement of fluid from the pulp to the periphery due to, for example, insufficient cooling or drying of dentine. If the irritation is short-lived and a little traumatic, the pulp tissues usually regenerate. If repeated or excessive, irritation can cause irreversible changes in the pulp.

Then mechanical irritation of the tooth hard tissues — obliteration of the dentineal tubules, formation of crater-like surface defects in dentine, increase in microhardness of the prepared dentine by 30 % as a result of calcification of the tooth tissues, increase in the number of round-cell elements (one day after preparation) — occurs. The vascular reaction of the tooth pulp is expressed in the expansion and overflow of blood vessels with the formation of hemorrhagic infiltrates as a result of rupture of the vessels and the passage of blood elements through their intact wall, increasing the excitability of the pulp.

In the process of dental intervention in a patient, it is possible that the function of the patient's cardiovascular system and endocrine apparatus may be disturbed.

To prevent these complications, the dentist must follow the following rules:

- to take and record the patient's complaint's and case history thoroughly;
- to know well the structure of hard dental tissues in normal and pathological conditions;
- to follow the basic principles and rules of preparation;
- to observe the speed and temperature regime of preparation;
- to know and correctly use modern technical achievements in dentistry.

The dentist is in the first risk group for contracting hepatitis and HIV. Not only the immunodeficiency virus, but also the causative agents of opportunistic infections: tuberculosis, cytomegalovirus infection, herpes simplex virus can be transmitted through the oral cavity due to saliva, blood and aerosols formed during the preparation of teeth. According to the scale of difficulty of labor of medical workers, developed by the main specialists of the Ministry of Health of the Republic of Belarus, the work of a dentist classified as the 4th category of difficulty (out of 6 possible). There are 5 industrial hazards that affect the body:

- presence of industrial dust;
- physical factors (vibration, noise);
- chemical factors (antiseptics, sealing, etc.);
- biological factors (acute and chronic intoxication);
- overstrain of individual organs and systems (diseases of the musculoskeletal system, peripheral nerves, blood vessels).

The work of a dentist is associated with the impact of all 5 factors characteristic of industrial hazards.

The professional work of a dentist is distinguished by high emotional, mental and physical stress. A wide range of causes contributing to the emergence of various diseases (eye damage, acoustic trauma, cloud aspiration, vibration injury, forced position, etc.) can be identified in the activities of the dentist.

The most important production factor of the dentist’s work is the lighting of the workplace; the dentist's general health, vision. The effectiveness of the work is directly linked on the quality of lighting of the working place. The specificity of the “visual” work of the dentist lies in the fact that the doctor deals with a small operating area (approximately 1 cm^2) and objects of differences of the order of 0.1–0.3 mm. The visual work of the dentist belongs to the category of work of the highest accuracy, since the size of the head of the smallest bur is only 0.13 mm. The doctor sees the operative field in most cases in a dental mirror, the area of which is small and in order to distinguish the details of the pathological process, the doctor has to strain his eyes. It was established experimentally that after 3 hours of work, the visual acuityof the dentist is reduced by 10–15 %.

The work of the dentist contributes to a significant progression of short-sightedness (myopia), especially with an increase in professional experience and a frequent occurrence of asthenopia (a symptom complex manifested by eye fatigue, pain in the forehead and temples). Of course, the initial eye health is also important.

Vision deterioration is also affected by dust and foreign bodies that occurs during tooth preparation, which often leads to infection of the eyes. Long-term medical manipulations require a high concentration of vision.

To prevent eye diseases, electrical reflexors are necessary for dental chairs without the blinding effect on the patient’s eyes and the doctor, special safety glasses and accessories. To prevent light readaptation, which is tedious for the doctor’s vision, the lighting of dentist’s workplace can’t be more than 10 times brighter than general lighting in the room.

The dentist encounters noise in the process of working with a turbine handpiece, from compressors and other equipment. Noise is a random mixture of sounds of different strengths and frequencies. It has a certain spectrum, expressed in hertz, and intensity — the level of sound pressure, measured in decibels.

For a human being, the range of audible sounds is determined in the interval from 16 to 20 000 Hz. The auditory analyzer is most sensitive to the perception of sounds with a frequency of 1000–3000 Hz (speech zone).

Chronic noise loading can cause:

- reduction of hearing sensitivity, pain in the ears;
- increase in blood pressure;
- change in the function of digestion, expressed in a decrease in the acidity of the gastric juice, appetite;
- cardiovascular insufficiency;
- irritability;
- headaches, dizziness;

- memory loss, fatigue;
- decrease in concentration of attention;
- negative changes in a person's emotional state, even stressful ones.

The maximum permissible noise level is considered to be 60 dB.

An especially significant impact on the dentist's body is characterized by bacterial aerosol which has both big and fine fractions. It is formed during the preparation and in the process of removing dental deposits with an ultrasonic scaler. Being in this cloud not only the doctor's and the assistant's, but also the patient body is subjected to infection. To ensure proper disinfection, the room must be quartzed for 30 minutes 2 times a day (after each shift), aired and provided with supply-and-exhaust ventilation with air-exchange ratio 3 times per hour for exhaust and 2 times per hour for supply of air.

Vibration loads, especially when working with turbine machines, are very high. Vibration affects mainly the doctor's hand and arm, holding the working vibrating tool. The degree of its impact on the body depends on the state of the body, on the direction of vibration, body position, duration of exposure. Vibration is actively perceived by the mechanoreceptors of the skin and the vestibular apparatus; with time, changes in the corresponding centers of the spinal cord and brain can occur. The result of such an effect is impairment of the cardiovascular system, disorders of the peripheral circulation, metabolic disorders, changes in the nervous system.

During preparation and other activities, the work of the dentist and his assistant is characterized as intense, mental-emotional, with a pronounced static load. The work of the dentist is associated with a high load on certain muscle groups, tension in the joints, plus the effect of vibration. There is also a static tension in the phalangeal muscles of the fingers. This complex stimulates a variety of disorders in the musculoskeletal system. Dentists do the work mostly in a sitting, less frequently standing position. The standing working position is not rational. It leads to a constant and uneven load on the lower limbs, varicose veins and abnormal curvature of the spine. There is also a restriction of the mobility of the chest and prolonged tension in the back, neck and shoulders. Therefore, the work is more rational in a sitting than in a standing position, but is also very tiring during the day and can lead to undesirable disturbances in the musculoskeletal system, to congestion in the abdominal organs and pelvis.

The combined effect of all the above factors contributes to an increased impact of each of them. Therefore, the work of the dentist belongs to the highest class of harmful nature of labor.

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CONTENTS

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Полонейчик Николай Михайлович
Палий Лариса Ивановна
Манак Татьяна Николаевна
Петрук Алла Александровна

МЕТОДЫ ПРЕПАРИРОВАНИЯ ТВЕРДЫХ ТКАНЕЙ ЗУБОВ

METHODS OF PREPARATION OF HARD DENTAL TISSUE

Учебно-методическое пособие

На английском языке

Ответственный за выпуск Н. М. Полонейчик
Переводчик А. А. Петрук
Компьютерная вёрстка Н. М. Федорцовой

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