Chapter 5

MODERN FILLING MATERIALS USED IN THE CLINIC OF CONSERVATIVE PEDIATRIC DENTISTRY

Modern filling materials are divided into five groups.

1. Materials for temporary fillings.
2. Materials for medical and insulating liners.
3. Materials for permanent fillings:
   - cements;
   - composite materials;
   - compomers;
   - amalgam.
4. Materials for root canal filling.
5. Dental sealants.

Requirements for the "ideal" filling material were formulated at the end of the XIX century by Miller and they have not lost their relevance until now including some additions. The "ideal" filling (restoration) material should:

– be chemically resistant, minimally soluble, that is, not amenable to chemical transformations, not to be destroyed and not to dissolve under the action of saliva, liquid food, dentin liquid;
– be mechanically strong, as in the process of chewing there are significant loads on the filling (30–70 kg);
– look like natural teeth (color, transparency, surface gloss, etc.);
– be resistant to abrasion (abrase at the same rate as tooth enamel);
– fit tightly to the walls of the carious cavity (adaptation to the walls) – have a good marginal fit due to the stability of shape and volume, and adhesion –micromechanical retention or chemical bond of the material with tooth tissues and other filling materials;
– maintain its shape and volume in the oral cavity for a long time, not to shrink, thus ensuring the stability of filling and the preservation of anatomical shape of the tooth;
– have good manipulative properties: sufficient plasticity, long working time, be easily entered into the carious cavity, not stick to tools, etc.;
– be minimally dependent on moisture in the process of filling and hardening;

– be safe for the pulp, hard tooth tissues and mucous membranes of the oral cavity (biocompatibility of the filling material);
– not contain toxic components harmful to the health of patient and medical personnel, be environmentally friendly;
– have an anticariogenic effect to prevent recurrence of caries on the border of filling with hard tissues of the tooth;
– have a low coefficient of thermal conductivity to eliminate thermal irritation of the pulp during intake of hot or cold food;
– correspond to the coefficient of thermal expansion of hard tooth tissues;
– be radiopaque and provide the possibility of objective quality control of fillings and detection of recurrent caries in the long term after treatment;
– have a long working life, not have special requirements for use, storage and transportation.

Even though modern filling materials already meet most of these requirements, the "ideal" filling material still does not exist.

DENTAL CEMENTS. DENTAL AMALGAM

Dental cements – filling materials consisting of powder and liquid. In case of their mixing, a homogeneous plastic mass is formed, which after hardening acquires a stone-like structure. There are following types of dental cements (Smith D. C., 1995):

1. Phosphate cements:
– zinc-phosphate;
2. Phenolate cements.
3. Polycarboxylate cements:
– zinc-polycarboxylate;
– glass-ionomer.
4. Acrylate.

In the practice of pediatric therapeutic dentistry phosphate, phenolate and polycarboxylate cements are more often used.

Work with dental cements consists of the following stages: mixing, entering mass into carious cavity and modeling of the filling. When working with dental cements it is advisable to be guided by the following concepts.

Mixing time – is recommended or maximum allowed time for mixing cement components to form a homogeneous dough-like consistency and is clearly indicated in the instructions for each material.

Working time – the time during which cement mass retains the properties optimal for application to the carious cavity and filling modeling. It is determined from the beginning of mixing material at room temperature until the appearance of increased viscosity in the filling process. It is not recommended to carry out any manipulations with cement after the end of its working time.

Table 5.1. The chemical composition of dental cements

Powder	Liquid	
	Phosphoric acid	Polyacrylic acid
Zinc oxide	Zinc-phosphate cement	Polycarboxylate cement
Aluminosilicate glass	Silicate cement	Glass-ionomer cement

Hardening time – the time during which initial hardening of the cement mass occurs. During this time, the cement mass should not come into contact with saliva. The cement mass can be modeled and processed: grinding off and polishing. The hardening time is calculated from the beginning of mixing the cement mass. For different types of dental cements, it is different and is usually indicated in the instructions to the material. After the hardening time has passed, the primary treatment of filling can be carried out. However, the final treatment is best carried out in the next visit.

Cement thickening time – the time during which chemical reactions are completed in cement and its final chemical structure is formed.

PHOSPHATE CEMENTS

Zinc-phosphate cements

Zinc-phosphate cements (ZPC) belong to the group of mineral cements used in dentistry for more than 100 years. The first phosphate cement was developed by Osterman in 1832.

ZPCs consist of powder and liquid. The powder contains 75–90 % zinc oxide, as well as magnesium oxides (5–13 %) and silicon (0.05–5 %). The liquid is an aqueous solution of 45–64 % orthophosphoric acid, for partial neutralization of which aluminum and zinc compounds are added. Zinc slows down the reaction between powder and liquid, which ensures sufficient working time for zinc phos- phate cement. When the powder and liquid are mixed, an exothermic chemical reaction occurs, resulting in the formation of zinc phosphate. The solidified ma- terial is powder particles in a matrix of zinc phosphate. Due to the rapid neutralization of free phosphoric acid, phosphate cement has almost no irritating effect on the pulp, that is, it is relatively safe.

Zinc-phosphate cements (ZPC) are: “Adhesor” (“Spofa Dental”, Czech Repub- lic), “Zn Phosphate” (“PSP Dental”, UK), etc.

Indications for use of zinc-phosphate cements. ZPCs are used in the modern practice of pediatric therapeutic dentistry:

– as insulating liners to protect pulp in primary and permanent teeth;

– for permanent fillings in primary teeth at the stage of root resorbtion (1–1. 5 years before physiological change);

– as a material for temporary fillings for a long time (1–2 months).

Properties of zinc-phosphate cements

Positive properties	Negative properties
– *low toxicity;* – *thermal insulation capacity;* – *correspondence of the coefficient of thermal expansion (CTE) to the hard tissues of tooth;* – *radiopacity;*	– *low mechanical strength (low abrasion resistance);* – *weak adhesion to hard tooth tissues;* – *fragility;* – *solubility in oral fluid*

The technique of mixing and application of zinc-phosphate cements. The optimal ratio of ZPC components for mixing insulating liners and fillings is 2 measures of powder per 3 drops of liquid (Fig. 5.1). Mixing is carried out on the smooth surface of dry glass plate with a metal spatula. The measured amount of powder is first divided into 4 equal parts. One of the 4 parts is divided in half, and 1/8 of the powder of those formed is again divided into 2 equal portions, each of which is 1/16 of the total powder (Fig. 5.2). Then all portions sequentially (1/4, 1/4, 1/4, 1/8, 1/16, 1/16) are thoroughly mixed with the liquid for 45–60 seconds to form a homogeneous mass (Fig. 5.3). Properly prepared ZPC does not stretch beyond the spatula but breaks away from the cement mass and forms ridges of 1 mm long (Fig. 5.4). If the cement mass is too thick, a new portion should be mixed, since it is impossible to add liquid to the densely mixed cement mass. The working time for the ZPC is on average 2–3 minutes. The modeling of filling or the applying of an insulating liner should not exceed 1 min. The average harden- ing time in the oral cavity for ZPC is 7–9 minutes.

Fig. 5.1. The ratio of powder and liquid of zinc-phosphate cement

Fig. 5.2. Distribution of zinc-phosphate cement powder

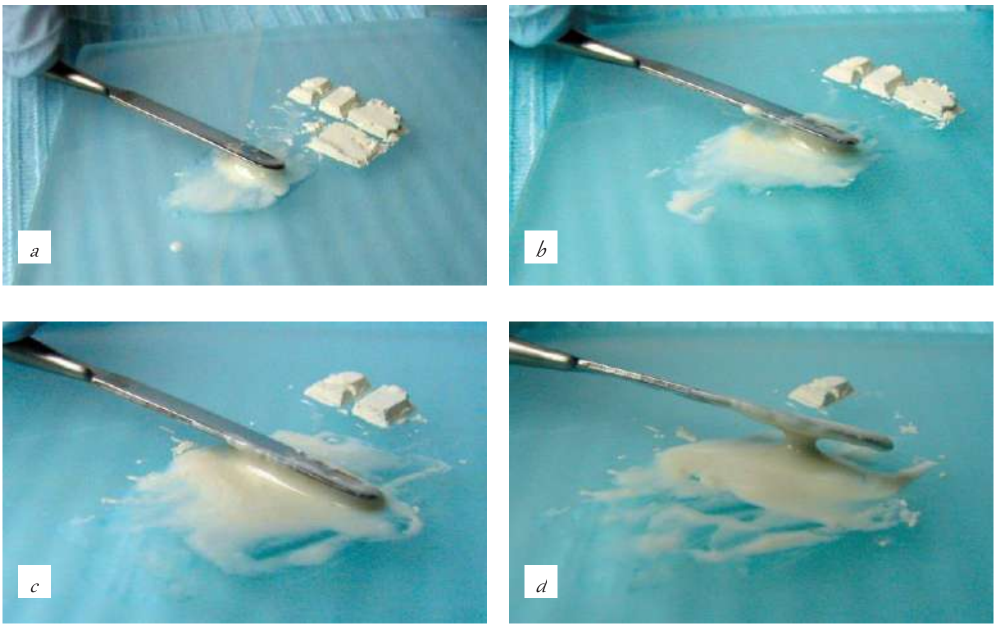


Fig. 5.3. The sequence of mixing the powder and liquid of zinc-phosphate cement:
a – the first 1/4 portion; *b* – the second 1/4 portion; *c* – the third 1/4 portion; *d* – 1/8 portion

Fig. 5.4. *Properly prepared mass of zinc-phosphate cement*

PHENOLATE CEMENTS

There are the following types of phenolate cements: zinc-oxide-eugenol and chelate (or calcium-salicylate) cements with calcium hydroxide.

Zinc-oxide-eugenol cements

Zinc-oxide-eugenol cement powder (ZOEC) contains mainly zinc oxide and about 1 % acetate and 1 % zinc sulfate to accelerate the hardening process. The liquid consists of purified eugenol or clove oil. Eugenol is an antiseptic that be- longs to the group of phenols and is of plant origin. The composition of clove oil includes from 70 to 85 % of eugenol. During cement mixing, a chemical reaction occurs between zinc oxide and eugenol with the formation of zinc eugenolate. This reaction requires moisture. After hardening, zinc-oxide-eugenol cement consists of zinc oxide particles, which are in a bound state in the matrix of zinc eugenolate, and a certain amount of free eugenol as well. It should be noted that the polymerization reaction of zinc-oxide-eugenol cement is reversible. If there is moisture, zinc eugenolate is hydrolyzed to eugenol and zinc hydroxide, that is, it is destroyed under the influence of oral fluid in the oral cavity.

Properties of zinc-oxide-eugenol cements

Positive properties	Negative properties
– antibacterial action; – analgesic effect;	– lack of strength; – solubility in oral fluid;

When applied to the bottom of the carious cavity, the sealing and antiseptic properties of ZOEC provide their anti-carious effect by stimulating the formation of reparative dentin.

Direct contact of ZOEC with the pulp of the tooth is undesirable because eugenol has an irritating effect. Eugenol inhibits the polymerization reaction of composite materials. Therefore, when restoring the anatomical shape of the tooth with composite materials, the ZOEC must be covered with an insulating liner.

ZOEC can be made immediately before use (*ex tempore*). For this purpose, zinc oxide powder and eugenol are used. The materials of industrial production are more convenient to use, for example “Caryosan” (“Spofa Dental”, Czech Re- public). Some of them contain strengthening substances: finely ground natural (rosin) or synthetic resins (polymethacrylate, polystyrene, polycarbonate) and catalysts. The composition of the liquid in addition to eugenol may include the above-mentioned soluble resins, acetic acid as a catalyst, as well as antimicro- bial agents, such as thymol. Strengthened ZOECs are: “Cavitec “(“Kerr”, USA), “Kalsogen Plus” (“Dentsply”, USA), “Zinoment” (“VOCO”, Germany).

The technique of preparation and application of zinc-oxide-eugenol ce- ment. To achieve optimal strength of the ZOEC, the powder-liquid ratio should be 3:1 or 4:1 (Fig. 5.5). The material is mixed on a dry glass plate with a metal spatula. The powder should be added to liquids in small portions (Fig. 5.6). Wet- ting of zinc oxide with eugenol is quite slow, so it must be intensively mixed with a spatula (on average for 1–2 minutes). When properly prepared, the ZOEC does not stretch beyond the spatula, but breaks off, forming ridges of 1–2 mm long (Fig. 5.7). When applying a pulp cap, the cement mass should be introduced into the carious cavity with a carver (Fig. 5.8) and compressed with a plugger, putting it evenly over the bottom.

Fig. 5.5. *The powder-liquid ratio of zinc-oxide-eugenol cement*

oxide-eugenol cement

Fig. 5.7. *Properly prepared mass of zinc-*

Fig. 5.6. *Mixing of zinc-oxide-eugenol cement*

Fig. 5.8. *A carver for application of zinc-oxide-eugenol cement into carious cavity*

Materials of industrial production harden in the oral cavity for 2–10 minutes and acquire maximum strength during this time. The final hardening of the ZOEC occurs only in 10–12 hours.

Indications for use of zinc-oxide-eugenol cement. ZOECs are used primarily as pulp caps in the case of:

– acute deep caries of permanent teeth at the stage of totally formed root;
– acute middle and deep caries of permanent teeth at the stage of an unformed root;
– acute deep caries of primary teeth.

ZOEC can be used for a temporary filling of carious teeth for therapeutic purposes in both primary and permanent teeth for a long time (1–3 months).

Chelate cements with calcium hydroxide (calcium-salicylate)

Calcium hydroxide-containing (calcium-salicylate) materials are phenolate type of cements. According to the mechanism of polymerization, there are two types of materials: chemical and light hardening. Cements of chemical hardening consist of two pastes. One of them contains calcium hydroxide, zinc oxide, and also their salts, placed in ethylentoluolsulfamide. The second paste contains substances that provide quick hardening of this material: calcium sulfate and titanium dioxide, which are in the liquid disalicylate ether of butane-1, 3-diol.

As a radiopaque substance, calcium tungsten is used.

The action of chelate cements with calcium hydroxide is due to a hardening reaction that takes place between calcium hydroxide, zinc oxide, and salicylic acid esters. An excess of calcium hydroxide in the material provides a high alkaline pH value of 12–13. As a result, calcium-salicylate cements have an antimicrobial effect, increase the reparative activity of pulp and promote the formation of re- placing dentin.

Calcium hydroxide-containing cements are characterized by a high degree of solubility in an acidic environment (for example, during etching), which is associated with their hydrolytic decomposition. Therefore, during constant filling of carious cavities with composite materials, a pulp cap made of calcium hy- droxide-containing cements should be covered with an insulating liner made of zinc-phosphate, polycarboxylate, or glass-ionomer cement.

Chelate cements based on calcium hydroxide chemical hardening include: " Calxyd "("Spofa Dental", Czech Republic), "Dycal" ("Dentsply", USA), "Calci- mol" ("VOCO", Germany), "Life" ("Kerr", USA), etc.

Properties of chelate cements with calcium hydroxide

Positive properties	Negative properties
– *stimulation of reparative dentin formation;*	– *lack of strength;*
– *antibacterial effect;*	– *a tendency to plastic deformation;*
– *rapid solidification;*	– *high solubility in oral and dentin fluids;*

Calcium-hydroxide-containing cements of photopolymerization include: “Lica” (“Dentamerica”, USA), “Ultra Blend Plus” (“Ultradent”, USA), “Cavalite” (“Kerr”, USA), “Calcimol LC” (“VOCO”, Germany).

The technique of preparation and application of chelate cements with cal- cium hydroxide. For the preparation of cement of chemical hardening of paste No. 1 and No. 2 (Fig. 5.9) squeeze out of tubes in the ratio 1:1 (Fig. 5.10). Mixing is carried out on paper plates with a plastic spatula (Fig. 5.11) for 15 seconds until uniform color (Fig. 5.12). The material should be applied to the bottom of the car- ious cavity in a small amount only in the projection of pulp horns with a special probe, a conventional probe or a small-sized plugger (Fig. 5.13). The working time for calcium-hydroxide-containing cements of this type is from 3 to 5 minutes. Solidification in the oral cavity occurs quickly, for 0.5–1 min. After hardening, the material must be covered with an insulating liner.

Calcium-hydroxide-containing cements of light hardening are applied to the bottom of the carious cavity with a thin layer (up to 1 mm) and polymerized with a light-curing unit for 20–40 s, after which an insulating liner should be applied to the mass.

Fig. 5.9. *Chelate cement with calcium hydroxide of chemical hardening*

Fig. 5.10. Ratio of pastes of chelate cement and calcium hydroxide

Fig. 5.11. Mixing of chelate cement with calcium hydroxide

Fig. 5.12. Properly prepared mass of chelate cement with calcium hydroxide

Fig. 5.13. A probe for the introduction of chelate cement with calcium hydroxide into carious cavity

Indications for use of chelate cements with calcium hydroxide (calcium-salicy- late). Chelate cements are used as pulp caps in the acute course of the carious pro- cess in primary and permanent teeth. Unlike zinc-oxide-eugenol cements, calci- um-salicylate cements can be used for the direct covering of pulp, as well as for further restoration of the anatomical shape of the tooth by composite materials, since they do not violate the polymerization processes of composites.

POLYCARBOXYLATE CEMENTS

Zinc-polycarboxylate cements

Zinc-polycarboxylate cements consist of powder and liquid. The powder contains zinc oxide and impurities of magnesium oxide (1–5 %). The liquid is a 30–50 % aqueous solution of polyacrylic acid or copolymers of acrylic acid with other organic acids, in particular, itaconic acid. When zinc oxide reacts with polyacrylic acid, zinc polyacrylate is formed. After hardening the cement mass contains the particles of free zinc oxide bound with an amorphous gel-like matrix.

Properties of zinc-polycarboxylate cements

Positive properties	Negative properties
– *chemical adhesion to hard tooth tissues;* – *biocompatibility with hard tissues of the tooth;* – *minimum toxicity;* – *radiopacity;*	– *lack of strength;* – *solubility in oral fluid;* – *unsatisfactory aesthetic properties*

Adhesion of zinc-polycarboxylate cements to hard tooth tissues is ensured by the formation of chelate compounds with the calcium of enamel and dentin apatites. High biological compatibility is explained by low toxicity and fast pH neu- tralization of cement mass. The ensurance of biocompatibility is also facilitated by the limited diffusion of polyacrylic acid due to the large size of its molecules.

The zinc-polycarboxylate cements (ZnPCC) include: “Adhesor Carbofine” (“Spofa Dental”, Czech Republic), “Carboco” (“VOCO”, Germany).

Indications for use of zinc-polycarboxylate cements. Zinc-polycarboxylate cements are used:

– as an insulating material in primary and permanent teeth;
– for permanent filling of carious cavities in primary teeth at the stage of root resorbtion;
– as a material for temporary fillings for a long time (1–2 months).

The technique of mixing and application of zinc-polycarboxylate cements. The ratio of components for the preparation of cement mass is 3 measures of pow- der and 5 drops of liquid (Fig. 5.14). Mixing the mass should be carried out on a smooth surface of a dry glass plate with a metal spatula. In contrast to zinc-phos- phate cements, polycarboxylate cement powder is introduced into the liquid in two portions for 30–40 seconds (Fig. 5.15, 5.16). Properly prepared zinc-poly- carboxylate cement forms a thick, shiny and viscous filling mass (Fig. 5.17). The mass must be introduced into the carious cavity in one portion. Working time for zinc-polycarboxylate cements is about 2.5–3 min. The modelling of filling and the introduction of an insulating cap is carried out within 1.5–2 minutes. Hardening time of zinc-polycarboxylate cements in the oral cavity — 6–9 min.

Fig. 5.14. The ratio of powder and liquid of zinc-polycarboxylic e cement

Fig. 5.15. The powder separation of zinc-polycarboxylic cement into portions

Fig. 5.16. Mixing of zinc-polycarboxylic cement

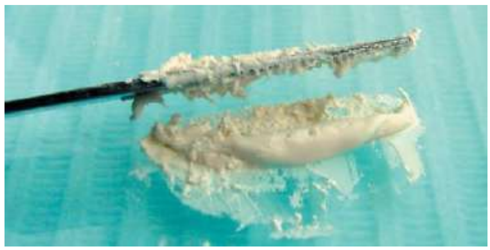


Fig. 5.17. Properly prepared mass of zinc-polycarboxylate cement

GIASS-IONOMER CEMENTS

Glass-ionomer cements (GIC) – dental cements of a new class, appeared in 1974 thanks to the development of A.D. Wilson and B.E. Kent, who combined the technology of making silicate and zinc-polycarboxylate cements.

The modern systematization of glass-ionomer cements used in clinical practice is based on the classification of J. McLean (1988). According to appointment glass-ionomer cements are divided into the following types:

– I – fixing (luting) – for fixing orthopedic and orthodontic structures;
– II – restorative (restoration) – for filling carious cavities;
– III – lining – for insulating liners;
– IV – glass-ionomer cements for root canal obturation.

According to form of release and the mechanism of solidification, the following groups of glass-ionomer cements are distinguished (Nikolaev A. I., Tsepov L.

M., 2009).

1 – traditional (classical) two-component GIC of chemical hardening (powder / liquid system), where the powder consists of finely ground fluoroalumosilicate glass with the necessary additives, and the liquid is an aqueous solu- tion of carboxylic acid copolymers.

2 – two-component aquacements of chemical hardening (powder/water system) are mixed in distilled water. The powder contains alumosilicate glass and lyophilized polyacrylic acid. When the powder is mixed with water, polyacrylic acid dissolves and the classical solidification reaction of glass-ionomer cement begins. The main advantages of such materials are easy mixing by reducing the viscosity of liquid, as well as inability to over- dose the amount of powder or liquid. However, the high initial acidity of anhydrous glass-ionomer cements can cause increased sensitivity of the tooth pulp after filling the carious cavity.

3 – hybrid GIC of double solidification.

4 – hybrid GIC of triple solidification.

Traditional (classical) glass-ionomer cements consist of two components – powder and liquid. The powder of glass-ionomer cement is represented by the finely ground calcium-aluminosilicate glass with a high content of fluorine (by weight up to 20–23 %). Its main components are silicon dioxide (SiO_2) and aluminum oxide (Al_2O_3) in a 2:1 ratio, as well as calcium fluoride (CaF_2). The com- position of glass in small quantities includes sodium and aluminum fluorides, calcium, or aluminum phosphates.

The radiopacity of glass-ionomer cements is provided by the addition of barium glass or metal compounds, in particular, zinc oxide. Increasing the content of calcium fluoride in powder reduces the transparency of material, but provides its caries-static properties by increasing the amount of fluoride.

Glass-ionomer cement liquid is the 47,5 % (40–55 %) aqueous solution of copo- lymers of three unsaturated carboxylic acids: acrylic, itaconic and maleic, which are biologically compatible with tooth tissues, thereby significantly less irritating to the pulp than phosphoric acid, which is part of phosphate and silicate cements. These high-molecular acids are used in glass-ionomer cements because their poly- mers have the largest number of carboxyl groups. It is due to these groups that the crosslinking of polymer chains takes place and the adhesion of cement to the hard tissues of tooth is ensured. The composition of liquid glass-ionomer cements also includes tartaric acid (5 %), which helps to increase the working time of cement.

In the process of glass-ionomer cement solidification there are three stages:

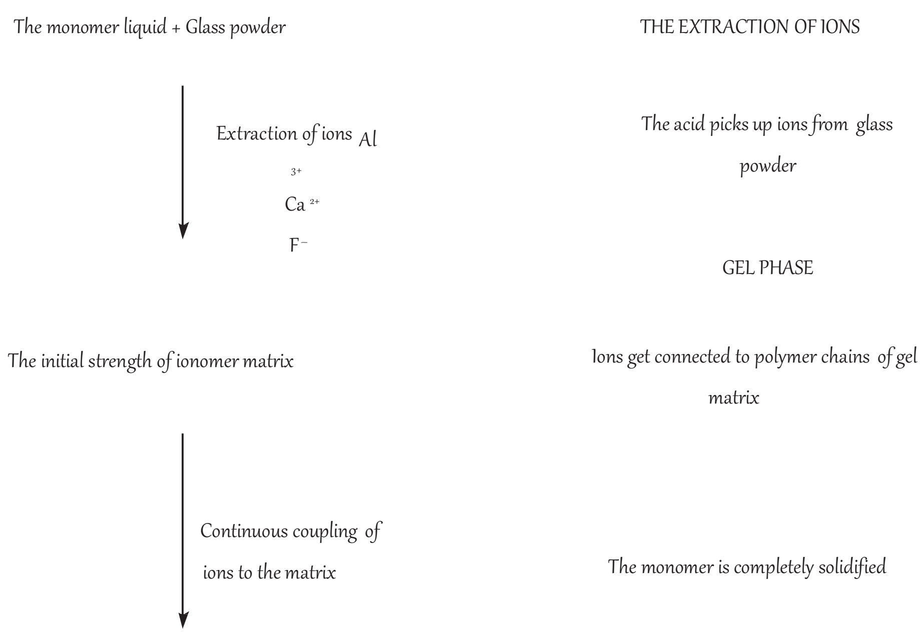
- I – dissolution (or hydration, the release of ions);
- II – thickening (primary gelation, initial unstable solidification);
- III – solidification (dehydration, maturation, final solidification).

To carry out these reactions, an aqueous medium is necessary. Mixing the liquid (acids) with the powder (alkali) first promotes release of soluble metal ions ($A1^{3+}$ and Ca^{2+}) from glass particles. These ions diffuse into surrounding aqueous solution. As a result, in the outer layer of each glass particle the number of metal ions decreases, turning this layer into a silicate gel.

With sufficient accumulation of metal ions in the solution, the second phase begins – gelation, as a result of which ions are connected to acid chains, forming bridges between them from metal salts.

The aqueous gel, which is formed as a result of above-mentioned reactions, acts as a matrix, surrounds the unreacted glass particles, uniting them into a single material. Once metal ions are blocked in the matrix, they become insoluble, so that the material hardens (scheme 5.1).

Due to gradual implementation of three main stages, the cross-spatial cross-linking of polymer acid molecules with help of calcium and aluminum ions occurs. As a result of formation of these bonds, a three-dimensional spatial structure of the polymer is formed. After final hardening, the cement mass structure consists of glass particles surrounded by silica gel, located in a polymer matrix of polycarboxylic acids. The final solidification and thickening phase of the GIC lasts for 24 hours. During this time, the transparency and strength of material are formed. At the final solidification stage (for the first 24 h), glass-ionomer cement is extremely sensitive to water. The reason lies in metal ions, which have not re-



SOLIDIFICATION PHASE

Formation of the final color, transparency and strength

The remaining ions are embedded in the matrix.

Scheme 5.1. Hhardening reaction of glass-ionomer cement acted and remain soluble, so they are very easily removed with water. This in turn leads to the material weakening and formation of a matte surface of the filling. To prevent weakening of cement mass, the surface of filling should be isolated for 24 hours with a special insulating varnish (chemical or light hardening).

Excessive drying of dentin also weakens the material, resulting in reduced adhesion, lost transparency and increased fragility. Therefore, before applying a filling from GIC, the dentin surface should not be overdried. It should be slightly moistened.

Properties of traditional (classical) glass-ionomer cements

Positive properties	Negative properties
– *chemical adhesion to hard tooth tissues;* – *high biocompatibility (non-toxic);* – *caries-static effect;* – *sufficient mechanical strength and elasticity;* – *correspondence of CTE to hard tooth tissues;* – *low thermal conductivity;*	– *slow solidification;* – *fragility;* – *low abrasion resistance;* – *insufficient aesthetic properties (poor transparency);* – *sensitivity to both excess and lack of moisture*

Chemical adhesion of glass-ionomer cements to dentin, enamel and cement is their most important property, and this makes it possible to prepare carious cav- ity without formation of special retention points. Chemical adhesion is provid- ed by two mechanisms. The first is the chelate type of compound of carboxylate groups of polyacrylic acid molecules with the calcium of enamel apatites and den- tin. The second one happens because of the formation of hydrogen bonds between polycarboxylic acid and the active groups of collagen fibers of dentin. As a result, the absorption of polyacrylic acid occurs on dentin collagen. The total force of GIS connection with hard tissues of tooth can reach 8–12 MPa.

The GIS adhesion to hard tissues of tooth occurs only during the first phase of solidification reaction – dissolution (release of ions), that is, immediately after mixing powder and liquid. During this period, the cement mass has a characteristic glossy surface and connects well with a slightly moistened dentin surface. At the beginning of the second phase – thickening (primary gelation), mass surface becomes matte. These changes indicate the beginning of unstable solidification of material. Therefore, the introduction of GIC into carious cavity and modeling of filling must be completed before the beginning of thickening phase, when the cement mass has a glossy surface.

High biocompatibility (non-toxicity) is provided by a significant molecular weight of polyacrylic acid. Its molecules, due to their large size, cannot diffuse through the system of dentine tubules and have an irritating effect on the pulp. The non-toxicity of GIC makes it possible to use them without a cap or as a cap material. However, during the treatment of acute deep caries, the preliminary application of a pulp hydroxy-calcium-containing cap is mandatory.

Fluorine-dependent caries-static effect of glass-ionomer cements is provided due to prolonged fluoride release, as well as the formation of a layer of fluorapa- tites at the border between the filling and tooth hard tissues.

The release of fluorine ions begins immediately after mixing the GIC powder with liquid. The highest activity of this process is observed during 24–48 hours after filling of carious cavity, than the rate of fluoride ions is sharply reduced. The formation of so-called fluoride reserve is observed for another 1 month after hardening of material. Fluorine release in the long term (within 6–12 months) occurs at a very low level due to dissolution of fluoride salts.

Antibacterial properties of glass-ionomer cements are associated with the ac- tion of fl orine.

Sufficient mechanical strength and elasticity. GIC has high compressive strength and high elasticity, due to which they withstand occlusive loads and to some extent compensate for polymerization shrinkage of composites. The coeffi- cient of thermal expansion of GIC is approximately the same as that of the hard tissues of tooth.

Chemical adhesion to filling materials (composites, amalgams, eugenol) is ex- plained by the ability of GIC to form chelate and hydrogen bonds with various substrates.

Satisfactory aesthetic properties of glass-ionomer cements make it possible to use them as a permanent filling material in both primary and permanent teeth.

Disadvantages of traditional glass-ionomer cements include the long thicken- ing of cement mass. Although the hardening of cement mass in oral cavity occurs within 3–6 minutes, its final thickening lasts for 1 day. Only after 24 hours, the material becomes insensitive to external influences. On the 1st day after filling, the "classic" GIC has several vulnerabilities: sensitivity to moisture, drying, me- chanical influences and vibration, as well as the possibility of violation of chem- ical composition of immature cement mass when it is etched with orthophos- phoric acid. Therefore, when applying an insulating cap from the "classic" GIC permanent filling with composite material has to be carried out during the next visit. In addition, traditional GICs have lower strength properties than composite materials, as well as lower abrasion resistance. Their aesthetic properties are also significantly inferior to composite materials.

In modern practice of pediatric therapeutic dentistry, types II and III of GIC are most often used. Type II (restoration) of traditional GIC includes: "Ketak Molar" ("3M ESPE", USA–Germany), "ChemFil Superior" and "Chem Flex" ("DentSply", UK), "Fuji II" i "Fuji IX" ("GC", Japan), "Ionofil" ("VOCO", Germany). Type III (fast-hardening, lining) of traditional GICs include: "Ionobond", "Aqua Cenit", "Aqua Ionobond" ("VOCO", Germany), "Baseline "("Dentsply", United Kingdom).

Indications for use of traditional (classical) glass-ionomer cements:

– filling of III, V classes carious cavities and root caries in permanent teeth;
– filling of I class carious cavities, which are not located in the zone of occlusal contact in permanent teeth;
– filling of I–V classes carious cavities in primary teeth;
– treatment of caries in primary teeth using ART-technique;
– application of insulating liners in primary and permanent teeth;
– formation of the basis of restorations in the case of filling with composite materials ("sandwich" filling technique);
– temporary filling of permanent teeth defects for a long time;
– filling of hard tissues defects in teeth with non-carious lesions.

Technique of preparation and application of traditional glass-ionomer cements. To ensure the highest quality connection of GIC with hard tissues of tooth, it is necessary to clean the dentin surface. For this purpose conditioners are used. They should be non-toxic to the pulp, compatible with the chemical composition of GIC and water-soluble. Conditioners should not cause demineralization of enamel and dentin.

10–25 % aqueous solution of polyacrylic acid is used as a conditioner when filling the GIC. The conditioner should be applied for 10–30 seconds (according to the instructions) to bottom and walls of carious cavity with an applicator, then rinse the cavity with water for 20–60 seconds. Immediately before the start of filling, carious cavity should be dried so that it remains slightly moistened since the GIC is sensitive to dehydration.

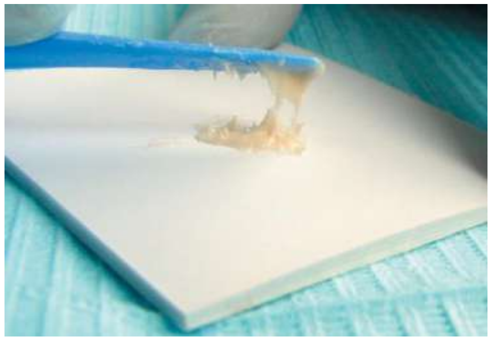
The optimal powder/liquid ratio for GIC of type II (restorative) is on average 3:1 (Fig. 5.18). For GIC of type III (lining), the ratio of powder and liquid varies from 1.5:1 to 4:1 depending on the purpose (insulating liner or base

Fig. 5.18. *The ratio of powder and liquid in the formation of glass-ionomer cement*

Fig. 5.19. *Measuring of glass-ionomer cement powder*

Fig. 5.20. *Distribution of glass cement powder*

Fig. 5.21. *Mixing of glass-ionomer cement*



Flg. 5.22. *Properly prepared mass of glass-ionomer cement*

for restoration). It should be noted that the GIC is very sensitive to the violation of its components ratio. Reducing the amount of powder slows down the solidification process of material, reduces its strength, and increases the degree of solubility in oral fluid. Overdose of powder can cause development of teeth hypersensitivity after filling. GICs belong to hydrophilic materials. Therefore, during solidification with a shortage of moisture, they can take it from the pulp, thus causing increased sensitivity of the tooth after filling.

Mixing of GIC is carried out on a smooth surface of a dry glass or paper plate. The measured amount of powder (Fig. 5.19) is divided into two equal parts (Fig. 5.20). The first portion of powder is mixed with the liquid using a plastic spatula for 10–20 seconds (Fig. 5.21). After formation of a homogeneous mass, the second part of powder is added to it and mixed for the next 20 seconds. Properly prepared material has the appearance of a homogeneous mass with glossy surface (Fig. 5.22). During this period, at the boundary of dissolution and thickening phases, GIC should be introduced into carious cavity in one portion. This manipulation is desirable to perform with plastic tools because it sticks to metal ones.

The working time for most GIC is from 1.5 to 3 min (average 2 min). At the beginning of solidification phase, the surface of filling mass dims, loses its gloss and transparency. Further work with the material during this period can lead to disruption of formed cement mass structure, as well as worsen its adhesion to hard tissues of tooth. The time of solidification of restorative GIC in oral cavity is 3–4 minutes; and the lining – 4–5 minutes.

General rules of work with glass-ionomer cements

1. Properly mixed cement mass should have a paste-like consistency and shiny surface. These properties indicate the presence of free polyacrylic acid in the filling material, which provides chemical adhesion of GIC to the hard tissues of tooth. If cement mass has lost its gloss, it should not be used.
2. Optimal solidification of GIC occurs in the absence of moisture (the filling should not come into contact with oral fluid). During initial solidification, cement mass loses its moist gloss and acquires an elastic rubber-like consistency. During this period, it should not be subjected to mechanical stress, as this impairs the adhesion of material to the hard tissues of tooth.
3. GIS filling should be isolated from the oral fluid for 24 hours, as this material is extremely sensitive to moisture. For this purpose, special varnishers of chemical or light hardening are used. The varnish must be applied to the filling with an applicator and evenly distributed with a jet of air. Insulation of the filling surface for 24 hours prevents erosion of aluminum ions and prevents destruction of the three-dimensional structure polymer formation.
4. Pretreatment (grinding) of GIS filling is carried out with carborundum stones and flexible abrasive discs only after the completion of primary solidification of filling material, that is, in 4–5 minutes.
5. The final treatment (polishing) of filling is carried out no earlier than 24 hours, that is, during the next visit. To do this, use diamond heads, polishing discs, strips, as well as rubber cups with finely abrasive polishing paste. Final processing of the filling immediately after it hardening is undesirable. This can lead to cracking of cement mass due to microvibration of tools for polishing and breaking the filling marginal fit.
6. It should be remembered that after 2–3 weeks the filling from GIC darkens a little. Therefore, for a better aesthetic effect, it is advisable to choose a lighter shade of GIC.

Hybrid GICs were created for elimination of the shortcomings inherent in traditional GIC, while maintaining their positive properties. A feature of hybrid materials is the introduction of polymer (methacrylate) resin into their composition, which hardens under the action of light. The hybrid powder of GIC, as well as a traditional one, contains fluoroaluminosilicate glass. The liquid is a solution of copolymers of polycarboxylic acids modified by a certain amount of unsaturated methacrylic groups. These modified radicals allow molecules to get connected under the action of light. The first represen- tatives of this group of materials were hybrid GIC of double hardening. These include: “Vitrebond” (“3M” ESPE, Germany), “Fuji II LC” (“GC”, Japan), “Vivaglass Liner” (“Vivadent”, Switzerland).

These materials have two independent mechanisms of hardening. Immediately after powder and liquid mixing , the typical for GIC slow chemical solidification reaction begins. Under the action of photopolymer lamp light, a rapid “composite” hardening reaction of the polymer matrix occurs. As a result, dense polymer frame is formed, which ensures the strength and stability of material at the initial stage of hardening. The chemical hardening reaction continues for 24 hours. As a result, glass-ionomer matrix is connected to the polymer matrix. Thus, a strong homogeneous cement mass is formed. Hybrid GIC unlike a traditional one have sufficiently long working time after mixing and quickly harden under influence of light (for 20–30 seconds) without formation of microcracks, well connected with hard tissues of tooth, are more durable and less sensitive to moisture and dehydration.

Polymer matrix of double hardening hybrid GIC is formed only under the action of light. Therefore, they should be introduced in layers, whose thickness does not exceed 2 mm, into carious cavity. For the same reason, hybrid GIC of double hardening cannot be used to fix caps, crowns and intra-channel pins.

Further improvement of the GIS structure was due to the involvement of additional mechanisms of hardening, which contributed to creation of a hybrid GIC ***of triple hardening*** – “Vitremer” (“3M ESPE”, Germany). It was composed of microcapsules with catalysts for the reaction of chemical hardening of poly- mer matrix. As a result, the hardening mechanism of this material is threefold and consists of:

– acid-base reaction (as in traditional GIC);
– fast photopolymerization under the photopolymer lamp action;
– chemically activated polymerization due to the catalyst contained in microcapsules.

In case of mixing powder with liquid, the acid-base chemical reaction of hardening occurs, which gives material characteristic properties of the GIC: chemical adhesion, high biological compatibility and prolonged fluorine extraction. This reaction lasts for a day inside the polymer matrix. Rapid light hardening of polymer matrix under the photopolymer lamp action provides a high strength of the material and ease of use. Chemically activated polymerization of free methacrylate radicals in areas inaccessible to light penetration guarantees optimal solidification of the entire cement mass. The reaction occurs due to destruction of microcapsules in the process of cement mixing, which is accompanied by the activation of catalytic system. The triple solidification mechanism makes it possible to introduce the material in one portion, even if the volume of carious cavity is large. Its presence significantly increases the strength of material, reduces its polymerization shrinkage and expands the indications for use.

"Hybrid" GIC compared to "traditional" one are less sensitive to moisture and dehydration, have better mechanical properties, harden without formation of microcracks. However, they are inferior to the "classic" materials in terms of such indicators as the strength of chemical bond with hard teeth tissues, fluoride extraction and anti-carious activity.

AMALGAM

Amalgam is an alloy of mercury with one or more metals. There are three kinds of amalgam: silver, copper and gold.

"Classic" silver amalgam consists of an alloy of silver (65–66 %), tin (29–32 %), copper (2–6 %) and zinc (up to 1%), which is mixed with mercury.

There are the following types of amalgam.

According to the size and shape of alloy particles:

- *I type* – particles (chips) have a needle-like shape and their dimensions do not exceed 160 microns. This form gives the amalgam rigidity in process of packing (condensation);
- *II type* – fine particles of spherical shape with sizes from 4 to 40 microns. This amalgam is easier to condense, hardens faster and is better polished;
- *III type* – mixed, formed by mixing the powder of two previous types. The ability of amalgam to condense is regulated by the change in ratio of above-mentioned components. The smaller size of alloy particles leads to faster amalgam hardening, high strength, better adhesion to the walls of carious cavity, smoother surface of material.

According to the content of copper amalgam alloys are distinguished:

- with a low copper content (up to 6 %);
- with a high copper content (6 % to 20 %).

Each of the amalgam components gives it certain properties:

- silver increases strength, increases corrosion resistance and reduces the fluidity of amalgam, but it also contributes to volumetric expansion of amalgam in the carious cavity;

– tin slows down the hardening process of amalgam and increases its plasticity, but reduces the strength and promotes corrosion of alloy;
– copper, like silver, increases strength, protects against corrosion, has antibacterial properties. Copper also increases the plasticity and provides a tight marginal fit of filling. However, copper contributes to volumetric expansion of amalgam and accelerates solidification process;
– zinc improves technological properties of amalgam, that is, provides the possibility of lapping and condensation of material, makes amalgam less fragile and more plastic, and also prevents the formation of oxides, but causes too much volumetric expansion of amalgam in presence of moisture;
– mercury "wets" the alloy particles, as well as determines the plasticity of material.

In amalgams with low copper content (up to 6 %), the following chemical reaction occurs:

$$\mathbf{Ag_3Sn + Hg \longrightarrow Ag_3Sn + Ag_2Hg_3 + Sn_7Hg.}$$

Amalgamation process of alloys with high copper content (up to 20 %) is happening on the formula:

$$\mathbf{Ag_3Sn + Hg \longrightarrow Ag_3Sn + Ag_2Hg_3 + Cu_6Sn5.}$$

Thus, the solidified amalgam may consist of such basic phases or intermetallic compounds:

– silver and tin alloy particles (Ag_3Sn) – γ-phase (15 %);
– silver and mercury compounds (Ag_2Hg_3) – $\gamma 1$-phase (74 %);
– compounds of tin and mercury (Sn_7Hg) – $\gamma 2$-phase;
– copper and tin compounds (Cu_6Sn_5) – ε(Epsilon)-phase.

Each of these phases is characterized by certain properties. The most

strong and stable phase is γ-phase. Phase-$\gamma 1$ is also quite strong and resistant to corrosion. Epsilon-phase is characterized by antiseptic properties, abrasion re- sistance. The most vulnerable is phase-γ2. It has low strength, increases the volu- metric expansion of amalgam and is prone to corrosion.

The majority of modern amalgams have high copper content, as a result of which there is no reaction between tin and mercury, that is, the weakest phase-γ2 is not formed. The strength of amalgam is 300–400 MPa.

Properties of amalgam

Positive properties	Negative properties
– high mechanical strength; – resistance to oral fluid; – ability to polishing	– high thermal conductivity (irritating effect on the pulp); – lack of adhesion; – discrepancy of CTE of hard tissues of the tooth; – volume change after hardening (shrinkage); – discrepancy to the color of enamel and dentin

Amalgams with high copper content include: “Tytin”, “Contour” (“Kerr”, USA), “Amalkap Plus” (“Ivoclar”, Germa- ny), “Septalloy” (“Septodont”, France).

Indications for use of amalgam in pediatric therapeutic dentistry:

- filling of carious cavities of classes I–II in permanent teeth;
- filling of class V cavities in perma- nent molars;
- filling of carious cavities of classes I–II in primary teeth at the stage of root stabilization.

Technique of preparation and application of amalgam. Amalgam is pre- pared in a special apparatus – a mixer for amalgam (amalgam mixer) (Fig. 5.23). A special two-chamber capsule with amal- gam (Fig. 5.24) consists of two parts. One part contains mercury, the other with powder (Fig. 5.25). When you scroll 90^o holes inside the capsule coincide and mercury is freely mixed with powder. After that, the capsule is fixed in amal- gam mixer. The mixing time for different types of amalgam is 15–60 s. After mix- ing, the capsule is opened and a ball of amalgam is obtained, ready for filling.

The strength of amalgam fillings

Fig. 5.23. *Mixer for amalgam*

Fig. 5.24. *Special capsules with amalgam*

Fig. 5.25. *Contents of a special two-chamber capsule with amalgam: powder and mercury*

Fig. 5.26. *Special amalgam-carriers for amalgam intsertion into carious cavity*

Fig. 5.28. *Carborundum heads for grinding of amalgam*

Fig. 5.27. *Pluggers with cutting for amalgam (amalgam carriers)*

Fig. 5.29. *Polishers for the finishing of amalgam fillings*

depends on the speed of filling. Therefore, material should be introduced into carious cavity as soon as possible after its preparation (within the first minute). Amalgam mass is introduced into carious cavity with an amalgam carrier or special syringe for amalgam (Fig. 5.26). Amalgam is introduced into carious cavity in small portions (3–5 mm) to reduce likelihood of voids in the filling material during its condensation and improve the marginal fit of filling. The first portion of amalgam should be carefully rubbed into the bottom and walls of carious cavity with special plugger with cutting (Fig. 5.27), then consistently make the following portions of material. They are also condensed with special plugger with cutting. Manipulation begins from center of carious cavity in the direction of its walls. Strength of filling and density of its marginal fit largely depends on the quality of condensation of amalgam. The carious cavity is filled with amalgam with slight excess.

After that, modeling of a still plastic amalgam filling is carried out. The anatomical shape is modeled, in particular, the occlusal surface of filling, fissures are formed. Excess of amalgam is always cut towards the hard tooth tissues using special tools (carvers) or sharp excavator.

Immediately after completion of modeling, that is, at the beginning of hardening of filling, its surface should be smoothed, carefully rubbing amalgam to the edge of enamel. Special attention should be given to removal of the excess amalgam, overlapping enamel on the edge of filling. This manipulation is necessary in order to prevent chipping of the excess of amalgam after its hardening, and therefore, violation of the marginal fit of filling.

The process of final hardening of amalgam continues for 24 hours. Final filling treatment is carried out in the next visit. Grinding is carried out by special carborundum heads of green color, abrasive discs and finishers (Fig. 5.28). Polishers, polishing heads, and soft brushes with polishing paste are used for polishing (Fig. 5.29). At the final stage, the surface of filling should be mirror.

Working with amalgam, you should strictly observe safety precautions, as mercury vapor is very toxic. The remains of filling mass should be carefully collected and placed in a special container with a saturated solution of potassium permanganate to neutralize mercury.

Control questions to subsection "Dental cements. Dental amalgam"

1. Describe the classification of dental cements.
2. Name the composition, main properties, indications for use and method of mixing zinc-phosphate cements.

3. Name the composition, main properties, indications for use and technique of mixing zinc-oxide-eugenol cements.
4. What is the composition, basic physical and chemical properties, indications for use and method of mixing of calcium-salicylate (chelate) cements?
5. Describe the composition, main properties, indications for use and method of mixing zinc-polycarboxylate cements.
6. Describe the groups, composition, basic physical and chemical properties, of glass-ionomer cements.
7. Describe advantages and disadvantages of glass-ionomer cements of different groups.
8. Name indications for use and describe the technique of mixing of glass-ionomer cements.
9. Describe the types of amalgam, its main components, positive and negative properties.
10. Name indications for use and describe the method of preparation of silver amalgam.

Test tasks to the subsection "Dental cements. Dental amalgam"

1. *Composition of dental cement powder includes zinc, magnesium and silicon oxides, the composition of liquid – an aqueous solution of orthophosphoric acid, as well as aluminum and zinc compounds. What group of dental cements does this filling material belong to?*

A. Zinc-phosphate — *B. Silico-phosphate*

C. Silicate — *D. Glass-ionomer*

E. Polycarboxylate.

2. *In a 7-year-old child in the fissures of the first permanent molars, carious lesions were found within the circumpulpal dentin. Dentist decided to use one of the dental cements as an insulating liner. What kind of cement powder can be mixed on an aqueous solution of acrylic acid copolymer?*

A. Silicate — *B. Silico-phosphate*

C. Zinc-phosphate — *D. Zinc-oxide-eugenol*

E. Polycarboxylate.

3. *Composition of dental cement powder includes zinc oxide, as well as zinc acetate and sulfate. As a liquid, purified eugenol or clove oil is used. The composition of which dental cement is given?*

A. Silico-phosphate — *B. Silicate*

C. Phenolate — *D. Polycarboxylate*

E. Zinc-phosphate.

4. For permanent filling of class I carious cavities in the second permanent molar of lower jaw in a 14-year- old child, dentist used silver amalgam. What component of amalgam provides its rigidity?

A. Copper
B. Tin
C. Mercury
D. Zinc.

5. In a 6.5-year-old child, carious cavity was found on occlusial surface of the 55 tooth within the mantle dentin. For permanent filling dentist chose one of the dental cements. Which of these cements has the highest adhesion to hard totth tissues?

A. Polycarboxylate
B. Glass-ionomer
C. Silicate
D. Silico-phosphate
E. Zinc-phosphate.

6. During stomatological examination of a 7-year-old child, carious cavity of class II by Black was found in the 85 tooth. Dentist used glass-ionomer cement of chemical hardening as a permanent filling material. In what terms should the final treatment of permanent GIS filling be carried out?

A. Immediately after hardening
B. In 4–5 min after hardening
C. In 20 min after hardening
D. In 12 h after hardening
E. In 24 hours after hardening.

7. In a 6-year-old child, carious cavity was found on medial contact surface of the 65 tooth within the mantle dentin. What kind of dental cement is it advisable to use for permanent filling?

A. Silicate
B. Polycarboxylate
C. Zinc-phosphate
D. Glass-ionomer
E. Silicophosphate.

8. A child of 12 years complains about presence of carious cavity in the left lower molar . Objectively: on occlusial surface of 36 tooth the carious cavity is detected within peripulpal dentine. What kind of dental cement should be used for a pulp capping?

A. Polycarboxylate
B. Phenolate
C. Silicate
D. Silico-phosphate
E. Glass-ionomer.

9. During an objective examination in a child of 10 years on distal contact surface of the 26 tooth, carious cavity was found, within the peripulpal dentin. What kind of dental cement should be used for an insulating liner?

A. Phenolate
B. Silicate
C. Silico-phosphate
D. Polycarboxylate.

10. A child of 8 years complains about the destruction of upper jaw teeth. Objectively: on vestibular surfaces in precervical area of the 16 and 26 teeth, carious cavities within mantle dentin were found. What kind of cement is advisable to apply for permanent fillings?

A Glass-ionomer
B. Zinc-phosphate
C. Polycarboxylate
D. Silico-phosphate

E. Silicate.

Correct answers to the test tasks to the subsection Dental cements. Amalgam

1 – A	2 – E	3 – C	4 – A	5 – B
6 – E	7 – D	8 – B	9 – D	10 – A

COMPOSITE FILLING MATERIALS

In modern therapeutic dentistry, composite filling materials are the main ones for filling and restoration of teeth. They appeared in 1962 as a result of the research conducted by R. Bowen. A composite material is a complex compound based on an organic polymer matrix in which an inorganic filler is added to improve the properties; these components are chemically related to each other by means of silanes (bipolar molecules of surfactants).

According to the definition of Philips R.W. (1973), the term "composite" refers to spatial three-dimensional combination or combination of at least two completely different components in one material. One of them is a soft organic polymer, and other is distributed in the polymer matrix as ground inorganic particles. The polymer phase is chemically active, the inorganic filler distributed in it is chemically inert.

The polymer matrix of composites (organic matrix) in any composite filling material is represented by a monomer. The monomer is Bis-GMA, or bisphenol glycidyl methacrylate, which has high molecular weight and is the basis of majority of composite materials. It was first used by Dr. Rafael L. Bowen in 1962 and it is sometimes described as "Bowen's resin" in the literature. Other monomers can also be used as a polymer matrix, such as the low viscosity polymer UDMA – urethan dimethyl methacrylate (performs the same role as Bis-GMA, but has less polymerization shrinkage, gives the material greater strength) and others.

The polymer matrix also contains:

1) polymerization inhibitor (hydroquinone monomethylether), which provides a long shelf life and optimal working time of the filling material;
2) polymerization initiator (catalyst) – a substance that provides the start, acceleration and activation of the polymerization process. In composite materials of chemical polymerization, benzoyl peroxide is used as the initiator of polymerization, and in photopolymer composite materials, camphoroquinone and some other chemicals are used;
3) additional catalyst (co-catalyst) improving polymerization processes (used only in self-curing composite materials);
4) activator (photoinitiator of polymerization), providing the start of polymerization process (present only in light-curing composite materials);
5) UV absorber, which improves color stability and reduces discoloration of the material when exposed to sunlight.

Volume of the polymer matrix in composite filling materials is about 30 %.

Inorganic (mineral) filler is used to improve the properties of composite materials, namely for:

– reduction of the polymerization shrinkage;
– prevention of deformation of the polymer organic matrix;
– reducing the coefficient of thermal expansion;
– decrease of the sorption of water;
– increaing the mechanical strength of material and load resistance;
– improving aesthetic properties of material, as an index of light refraction and translucence of the filler is close to the tooth enamel.

In most composites, ground particles of radiopaque barium glass are used as a filler. Quartz, colloidal silicon with addition of lithium, barium or strontium can also be used to improve the optical properties of material.

The main properties of filler that affect the quality of composite are:

1. The particle size of filler. This indicator affects the mechanical and aesthetic properties of material. There is the dependency: composite material with smaller particle size of filler has better ability to polish and achieve the dry gloss of filling material but it has worse mechanical strength. Conversely, increase in particle size of filler is accompanied by the increase in mechani- cal strength of restoration, but the aesthetic properties (ability to polish and achieve dry gloss) deteriorate. The size of filler particles in various compos- ite materials is in the range of 0.04–45 microns.
2. The material from which filler is made (quartz, barium glass, silicon dioxide, porcelain flour and other substances).
3. Particle shape. In most composite materials, filler is represented by irregularly shaped particles. Some manufacturers prefer synthetic fillers with spherical particles. By changing particle size and material from which the filler is made, you can change the properties of composite.

Surfactants (silanes, finishing agents). From a chemical point of view, they are organic silicon compounds. The surface of filller is treated with silanes. They are bipolar binding agents, connected by a chemical bond, on the one hand, with filler (particles of glass, quartz and silicon), on the other – with organic matrix. Silanes are included in the composition of composite materials in order to im- prove the connection of inorganic particles with organic base and formation of chemically bound monolith. Due to this, composite materials have increased me- chanical and chemical resistance and strength, reduced water absorption of the material, increased resistance to abrasion.

Classification of composite materials

According to the polymerization method all composite materials are divided into following groups:

- self-curing;
- light-curing;
- heat-curing (used for manufacture of inlays in laboratory);
- dual-curing (light + chemical; light + thermal).

According to filler particles size, composite materials are divided into:

- macrofiller (particles from 8–45 microns);
- microfiller (particles size 0.04–0.4 microns);
- hybrid (filler particles of different sizes – from 0.04 to 5 microns, average particle size 1–2 microns);
- microhybrid - particle size from 0.04 to 1 micron, the average particle size 0.5–0.6 microns;
- nanofilled – nanocomposites (created using nano-technologies): true nanocomposites and nanohybrid composites. Particle size from 0,005 to 0,01 microns.

According to consistency composite materials are divided into:

- traditional regular consistency;
- flowable;
- condensable (packable).

According to amount of filler composite filling materials are divided into:

- highly filled (contain more than 65 % of inorganic filler);
- low-filled (contain less than 65 % of inorganic filler).

According to purpose composite materials are divided into:

- for filling of chewing teeth;
- for filling of front teeth;
- universal composites.

According to clinical purposes:

- type I – composite materials for loaded restorations;
- type II – composite materials for unloaded restorations.

Polymerization of composite filling materials

The process of polymerization of composite filling materials proceeds by combining relatively large molecules of the organic matrix into the three-dimensional high-molecular structure.

Self-curing composite materials (or self-hardening resins, composites of chemical polymerization) are the two-component system ("paste / paste" or "powder / liquid"). The first component – main paste – contains the chemical initiator of polymerization (benzoyl peroxide), and the second – catalytic paste – the chemical activator (tertiary amines) (Fig. 5.30). When these components are mixed, the polymerization reaction occurs, which is completed by hardening of the material. The speed of polymerization is largely dependent on the amount of initiator, temperature and presence of polymerization inhibitors. Inhibition of polymerization by oxygen during mixing of material significantly reduces the reaction of transformation of monomer into polymer, which leads to high water absorption, polymerization shrinkage and relatively low strength of these materials. Clinically, this is manifested by a change of color of the filling, unsatisfactory margin adhesion, rapid wear of the filling surface.

Fig. 5.30. Kit of self-curing composite material "Charizma PF" (Heraeus Kulzer, Gemany)

The advantage of chemical type of polymerization is even polymerization regardless of the depth of carious cavity and the thickness of material. The curing time of self-curing composite material is 4–5 minutes. The disadvantage of self-curing composites is change time in color of the filling (yellowish or greenish tint) over time due to long-term cleavage of tertiary amines after hardening of the material.

Light-curing composite materials (or composites of photopolymerization, photopolymers) are the one-component system (Fig. 5.31). They are available in light-proof plastic syringes or in disposable capsules. Polymerization of light-curing resins is the same as in self-hardening, but the activation of polymerization occurs without using chemical activator, and with the help of photon (light) en-

Fig. 5.31 Kit of light curing composite material "Grandio"

(VOCO, Germany)

nergy of photopolymer lamp. As an initiator of polymerization, the light-sensitive substance camphoroquinone and an amine activator, which are part of the material, are used. The speed of polymerization depends on the amount of initiator, illumination time and light intensity. The degree and depth of polymerization to a certain extent depend on the color and transparency of composite. To achieve the sufficient degree of polymerization, composite materials should be illuminated for 30–40 seconds. Longer exposure to light has an adverse effect on both the material and the hard tissues of teeth, so the composite should not be illuminated for too long. After the end of illumination polymerization continues, composites acquire their maximum strength no earlier than in 24 hours.

Therefore, from a practical point of view, the filling is recommended to be mechanically processed no earlier than in 10 minutes after last illumination, and finishing treatment should be done during next visit – not earlier than in 24 hours after application.

Light-curing composite materials have a number of advantages over self-curing composites, namely:

- they do not require the mixing of components;
- they make it possible to combine materials of different colors in the process of filling;
- they allow to model a filling for a long time;
- polymerization takes place under the supervision of a doctor;
- they are more economical, because the filling consumes exactly as much material as needed;
- they allow to achieve higher degree of polymerization using light;
- they can significantly improve mechanical, esthetic and functional parameters of the filling.

The main disadvantage of light-curing composite materials is ***polymerization shrinkage.*** All composite filling materials have polymerization shrinkage, which is from 2 to 5 % of the volume of a portion of material that hardens. The reason for this phenomenon is decrease of the distance between monomer molecules during polymerization from 3–4 to 1.54 angstroms. In self-curing composite materials the shrinkage is directed to the center of filling and in the direction of tooth pulp (fig. 5.32), in light-curing composites – toward the light source (fig. 5.33). Polymerization shrinkage is the cause of "polymerization stress" – occurrence of stress at the border of filling material and hard

Fig. 5.32. Direction of polymerization shrinkage in the self-curing composite materials

tissues of tooth. Due to polymerization stress, there can be separation of filling material from the bottom or walls of carious cavity, as well as the occurrence of pain in a tooth after filling.

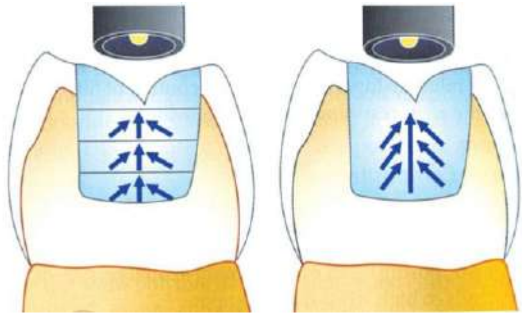


Fig. 5.33. Direction of polymerization shrinkage in the light-curing composite materials

In order to reduce and compensate for polymerization shrinkage in the process of fill- ing, it is recommended to use a number of practical techniques (Borysenko A. V., 2011; Kazakova R.V., 2018):

1) apply effective adhesive systems to increase the strength of the bond between filling material and hard tissues of tooth;
2) enter a composite material by portions and polymerize it. The optimal thickness of one portion of a composite material is about 1.5–2.0 mm, and the thickness of the first portion, which is applied to a bottom and walls of carious cavity, should be 0.5 mm;
3) apply the vectorial polymerization. Despite the fact that shrinkage proceeds in the direction of light source, the optimal direction of light flux through the hard tissues of tooth is perpendicular to the surface to which a composite is "glued". However, it should be remembered that light penetrates with significantly lower intensity through the enamel and dentin, so the time of illumination of materials through the layer of hard tissues of tooth increases by 2–3 times;
4) apply the "sandwich technique" of filling, when the basis of restoration is made of materials (for example, glass-ionomer cements), which don"t have polymerization shrinkage;
5) create an adaptive layer when the walls and bottom of carious cavity are covered with a thin layer of more elastic flowable composite;
6) apply the technique of "soft start", in which the power of light flux of curing lamp changes – first reduced, then increased to the optimal level.

Oxygen-inhibited layer is the surface layer of a composite material. The polymerization process in it is blocked by oxygen, which contacts the surface of composite during polymerization, so this layer consists of free radicals of a poly- mer matrix. It has the appearance of a shiny film on the surface of hardened composite. The oxygen-inhibited layer creates conditions for the qualitative addi- tion of a new portion of composite material to previously polymerized one. The introduction of a new portion of material interrupts the contact of surface with oxygen, the inhibited layer is integrated into new layer of composite material and completely polymerized, providing a connection between the layers of composite material. However, the layer inhibited by oxygen is highly permeable to food dyes, its strength is low, so it must be completely removed during the finishing treat- ment of filling of composite resin.

Types of composite filling materials. Properties. Indications for use

MACROFILLED COMPOSITE RESINS

In the historical aspect, macrophilic composite materials are the first com- posite filling materials with the particle size of filler (ground quartz) on average 15–30 microns (sometimes up to 100 microns) (“Evicrol” (Spofa Dental, Czech Republic), “Consize” (CI, USA), “Adaptic” (DentSplay, UK), “Visio-Fill”, “Vi- sio-Molar” (3M ESPE, USA), etc. The amount of inorganic filler per unit weight in them is 60–80 %.

Advantages:

– high mechanical strength;
– chemical resistance;
– sufficient marginal fit;
– radiopacity;
– satisfactory optical properties.

Disadvantages:

– poor polishability, lack of “dry gloss”;
– significant surface roughness;
– abrasion of a tooth-antagonist;
– low color fastness of the filling, more prone to staining

All disadvantages of these materials are associated with large particle size of filler. Surface roughness contributes to rapid abrasive wear of an organic matrix. In this case, inorganic particles become free and fall out of the matrix, thereby further increasing its roughness. Abrasive wear of the filling leads to deformation of occlusal surface, loss of interdental and occlusal contacts, deformation of the occlusal plane. The most significant disadvantage of macrophilic composite ma- terials is their unsatisfactory esthetic properties.

Indications for use:

– filling of I and II classes carious cavities, V class carious cavities in chewing teeth, that is, where high mechanical strength of the filling is required de- spite low esthetics;

– filling of class I carious cavities in frontal teeth (when carious cavity is lo- calized on the oral surface);
– restoration badly damaged crowns of the frontal teeth with subsequent lining of vestibular surface with a more esthetic materials, for example microfilled composite.

It should be noted that macrofilled composite materials are gradually being replaced by more modern and advanced composites in medical practice.

MICROFILLED COMPOSITE MATERIALS

Microfilled composite materials (resins) were created in late 70s of the last century in order to improve the ability of material to polishing. They contain the micro-filler consisting of very small (0.04–0.4 microns) silicate particles as inorganic filler. Sometimes synthetic silicon-zirconium or strontium-zirconi- um particles of spherical shape ranging in size from 0.1 to 0.3 microns are used. Thanks to micro-filler, the surface of polished filling is shiny and smooth as an enamel. In modern microfilled composites, the amount of filler is within 30-50 %. Microfilled composite filling materials include “Isopast “(Vivadent, Switzerland), “Degufill-SC”, “Degufill-M” (Degussa, Germany), “Durafill” (Kulzer, Germany), “Helio Progress”, “Helio-Molar” (Vivadent, Switzerland), “Silux Plus” (3M ESPE, USA).

Advantages:

– good esthetic;
– highly polishable;
– persistent dry gloss of filling;
– low abrasive wear.

Disadvantages:

– low hardness;
– poor mechanical properties due to more matrix content;
– high polymerization shrinkage;
– high coefficient of thermal expansion;
– more water absorption;
– poor color stability.

Insufficient mechanical strength is the significant disadvantage of microfilled composite materials. It is caused by very small particle size of the filler and sig- nificant polymer content. There is the dependency: due to smaller particle size of the filler, microfilled composite material has better ability to polish and dry gloss stability, but low mechanical strength.

High polymerization shrinkage and high coefficient of thermal expansion of microfilled composite materials are associated with lower filler content than in other composites (up to 30–60 % of weight and only 20–35 % of volume). In ad- dition, small filler particles interact poorly with organic matrix of the composite and tend to agglomerate (stick together), as a result of which they are unevenly distributed in the microphilled composite.

New impetus to the development of microfilled composites was made by the latest developments of Japanese company Tokuyama Dental, which has created two new microphilled composites with improved clinical and mechanical characteristics: "Estelite Σ", "Estelite Flow Quick".

Indications for use of microfilled composite resins:

- filling of class III carious cavities;
- filling of class V carious cavities;
- filling of non-carious defects of teeth without overlapping incisal edge;
- esthetic filling of class IV carious cavities as well as restoration of tooth crown after traumatic injuries (in combination with hybrid or macro – filled composites and parapulpar pins).

HYBRID COMPOSITE MATERIALS

Hybrid composite materials – the composite filling materials, which include mixture of filler particles of different sizes (from 0.04 to 100 microns) and different chemical composition (barium and strontium glass, fluorine compounds, etc.), due to which they combine the advantages of macro- and microfilled materials. Most hybrid composite materials contain 80–85 % of filler, which provides them with the same physical and mechan- ical properties as in macro- filled composites. These include "Composite Alpha-dent" (Den- tal Technologies, USA), "Vizio Molar" (VOCO, Germany), etc. (Fig. 5.34).

Fig. 5.34. Kit of hybrid composite material "Composite Alpha-Dent"

Microhybrid (restoration) composite materials – the variety of hybrid composite materials containing ultra-thin flexible filler with filler particle size from 0.04 to 1 microns (av-

Fig. 5.35. Restorative composite materials: *a* – "Filtek Z 250" (3M ESPE); *b* – "Charisma" (Kulzer); *c* – "Gradia direct" (GC); *d* – "Spectrum" (Dentsply); *e* – nanofilled composite "Ceram.X© Sphere TEC™ one" (Dentsply)

erage size 0.5–0.6 microns) and modified polymer matrix. Since size of the filler particles in these materials does not exceed 1 micron, they are called microhy- brid (restoration) composites. These include "Filtek Z 250" (3M ESPE, USA) (Fig. 5.35, *a*), "Valux Plus" (3M ESPE, USA), "Charisma" (Kulzer, Germany) (Fig. 5.35, *b*), "Gradia direct" (GC, Japan) (Fig. 5.35, *c*), "Amelogen Universal" (Ultradent, USA), "Spectrum", "Spectrum" TPH 3" (Dentsply, USA) (Fig. 5.35, *d*), "Ceram. X One" (Dentsply Sirona, Germany) (Fig. 5.35, *e*).

Advantages:

– high esthetics, ability to imitate the tooth structure;
– high physical and mechanical properties;
– exellent polishing and texturing properties;
– decreased polymerisation shrinkage;

– less water absorption.

Disadvantages:

– mechanical strength is insufficient for filling large cavities in areas where the filling has a significant chewing load;

– loss of the dry gloss after a while (5–6 months) (surface of the filling be- comes matte);
– in conditions of oral cavity, the material acquires more fluid consistency, which makes it difficult to model the restoration process;
– low elasticity of the material can cause polymerization stress.

However, despite these shortcomings, microhybrid composite materials can be considered universal restoration materials today.

Indications for use:

– filling of all five classes carious cavities according to Black;
– manufacture of vestibular aesthetic adhesive coatings (veneers).

NANOHYBRID COMPOSITE MATERIALS

The emergence of nanohybrid composites is associated with development of nanotechnology, which provides for "designing" of materials by constructing structures at the atomic level. For the first time nanotechnology (from Greek "nanos" – midget) was used in the production of nanofilled dental adhesives. Currently, the creation of composite restoration materials using nanotechnology is developing in two directions:

1. Improvement of microhybrid composites by modifying their structure with the filler with size of nanoparticles 20–70 nm (0.02–0.07 microns). As a result, the nanohybrid composite materials were created. Nanotechnology is not used in the manufacture of these composites. Nanohybrid composite materials have improved aesthetic characteristics as well as high mechani- cal strength in comparison with "traditional" restoration composites.
2. Creation of the true nanocomposites based on nanofillers of different types. The nanofiller in these materials is manufactured on the basis of nanotech- nologies using nanomers – particles of size from 20 to 75 nm. Thanks to na notechnology, nanoparticles can be partially agglomerated into nano- clusters – relatively large particles up to 1 micron. Particles larger than 1 micron are not used in the manufacture of these materials. Such com- posites are called "true nanocomposites", or nanocluster composites. True nanocomposites include "Filtek Supreme XT" (3M ESPE, USA), "Grandio" (VOCO, Germany). These materials have good mechanical properties, ex- cellent polishing ability, long-term stability of dry gloss of the restoration and can be used for filling cavities of all classes.

FLOWABLE COMPOSITE MATERIALS

Flowable composite resins (fluid, liquid composites) have the modified polymer matrix based on the high-flow resins. Filler content is 55–60 % by weight, particle size ranging from 0,02 to 0,05 microns. Most flowable composites contain a hybrid filler. The material is produced in syringes with an applicator in the form of needle for direct introduction it into carious cavity. Fluid composite materials include “Revolution” (Kerr, USA), “Aeliteflow” (Bisco, USA), “Filtec Flow” (3M, USA), “Arabesk Flow” (VOCO, Germany), “Latelux flow” (Latus, Ukraine), “Jen LC-Flow” (Jendental, USA) (Fig. 5.36).

Advantages:

– high fluidity and good adhesion to the surface;
– they can be easily introduced into carious cavity with a syringe and penetrate into hard to reach areas;
– they retain the desired shape, do not drain from the walls of carious cavity (have good thixotropic properties);
– highly elastic, which allows to compensate for polymerization shrinkage;
– radiopaque, which allows to control the quality of filling.

Disadvantagies:

– low mechanical strength, which limits their use in filling of areas with increased functional load;
– high polymerization shrinkage – up to 5–7 %, so it is recommended to introduce liquid composites into carious cavity with the layer of thickness of not more than 0.5 mm;
– low polishing ability and no dry gloss of the filling.

Indications for use:

– creation of adhesive layer to reduce a polymeriza- tion stress of composite materials;
– filling of small carious cavities on the occlusial surface of molars and premolars, especially in case of preventive filling;

a

b

Fig. 5.36. Flowable composite materials: *a* – “Latelux flow” (Latus, Ukraine); *b* – “Jen LC-Flow” (Jendental, USA)

– invasive and non-invasive fissure sealing;
– filling of class III carious cavities;
– filling of class V carious cavities in the precervical area of teeh;
– restoration of the marginal fit of fillings made of composite materials.

PACKABLE COMPOSITE MATERIALS

Condensable composite materials (packable composites) are manufactured on the basis of the modified dense polymer matrix and hybrid fillers with the particle size up to 3,5 microns. Condensable composites contain 80–85 % of special inorganic filler. These materials are created as an alternative to amalgam for simple and technological filling of carious cavities in chewing teeth. Packable composites are "Solitaire" (Heraeus Kulzer, Germany), "Filtek P-60" (3M ESPE, USA), "Prodigy Condensable" (Kerr, USA), "Synergy Compact" (Coltene, Switzerland) and others.

Advantages:
– increased wear resistance;
– condensability like silver amalgam restoration; the material does not flow and does not stick to instruments;
– decreased polymerization shrinkage (1–1.8 %); material can be applied and polymerized in horizontal layers without using the technique of vectorial polymerization;
– improved handling properties and simplicity of clinical use;
– greater ease in achiving good contact point.

Desadvantages:
– poor esthetic in frontal teeth;
– discrepancy of the color to hard tissues of tooth.

Indications for use:
– filling of I and II classes carious cavities by Black;
– filling of V class carious cavities in chewing teeth;
– filling of carious cavities by the method of "layer-by-layer" restoration (the main part of filling is made from the packable composites).

Compomers

Compomers are restoration materials that combine the properties of composite materials (term "Comp" in their name) and glass-ionomer cements ("Omers" in their name). The first compomer called "Dyract" was developed by Dentsplay (UK) in 1993.

From a chemical point of view, compomers are the combination of acid groups of glass-ionomer polymers and composite resins capable of photopolymerization.

The filler is particles of reactive strontium-fluorosilicate glass with addition of strontium fluoride, particle size – 0.2–2.5 microns. The filler is 52–60 %. In ad- dition to glass, the composition of compomers includes initiators, stabilizers and pigments. The organic matrix is represented by such monomer as in composite materials, modified by acid groups.

Currently, two generations of compomers are known (Inayat N., 2012). Compomers of the first generation include fluorine-silicon-aluminum-strontium glass as the filler. In structure, they are closer to glass-ionomer cements and are characterized by lower mechanical strength and high degree of abrasion. The filler of the second generation of compomers is fluorine-silicon-aluminum-barium glass. In addition to HEMA, they contain DCDMA monomers. They include the inorganic filler like composites – spherosil, which significantly increases mechanical stabili- ty and improves the optical properties of material, reducing its water absorption. *Setting reaction of compomers*. Compomers have two stages in polymerisation reaction. The first stage is polymerization of composite component, which occurs after light activation. This reaction causes primary hardening of the material. The second stage occures after initial setting of material, in contact with oral fluid - water absorption phase. The restoration absorbs water, an acid-based reaction (like in glass-ionomer) occurs within the polymer matrix and a thin glass-ionomer structure is formed. Slow release of fluoride also occurs here. But level of flu- oride release from the compomer is much lower than from traditional glass-iono- mer cements, due to low ability of compomers to exchange ions with tooth tissues and oral fluid.

Advantages:

– physical properties are very much similar to composites;
– optimal esthetics;
– fluoride release;
– compatability with adhesive systems that do not require etching of hard tooth tissues.

Disadvantages:

– low mechanical strength limits their use in areas of high masticatory load;
– lack of ability to polishing;
– microleakage, may be staining on “filling–tooth” border;
– no chemical adhesion to hard tooth tissues;
– limited fluoride release.

Indications for use:

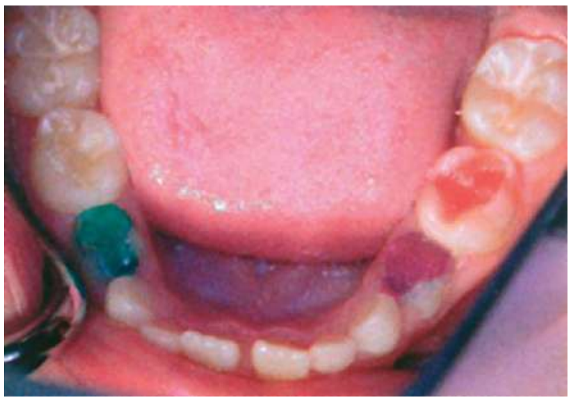
– filling of all classes carious cavities in primary teeth if cooperation of a child with dentist is good and there is possibility of ensuring dryness of carious cavity during entire time of filling;
– filling of III and V classes carious cavities in permanent teeth;

– filling of non carious defects of hard tooth tissues;
– filling of small carious cavities of classes I and II in permanent teeth after minimal invasive prepa- ration;
– temporary filling of I and II carious cavities in permanent teeth;
– pit and fissure sealing;
– dentin replacement using an open version of the "sandwich technique".

The stages of working with compomers repeat the stages of using composite materials, with the exception of the etch- ing of hard tooth tissues. In this case, it is advisable to use self-etching adhesive systems that do not provide for a sepa- rate etching step (for example, "NRC", "Prime & Bond NT").

Developments of compomeric technologies are aimed to improve physical and mechanical properties of compomers ("Dyract AR" Dentsply, UK), to create materials with increased fluidity ("Compoglass Flow" (Vivadent, Germany), "Dyract Flow" (Dentsply, USA)), fixing compomers with a chemical mechanism of hardness ("Dyract Cem", (Dentsply, USA)). Compomers specially designed for restoration of primary teeth have been created: these have different colors of filling material (gold, pink, blue, yellow, green, etc.), which causes the child's interest in the treatment process ("Twinky Star" (VOCO, Germany)) (Fig. 5.37).

a



b

Fig. 5.37. Kit of *"Twinky Star" compomers (a); type of fillings in primary molars (b)*

Dental adhesive systems

Adhesion (from lat. *adhaesio* – adhesion) – coupling of surfaces of dissimilar bodies. In dentistry term “adhesion” refers to the adhesion of dental material with hard tissues of tooth or other materials. There are three types of adhesion:

– mechanical – the mechanical connection of material with hard tissues of tooth;
– chemical – formation of chemical compound of material with dentin and enamel;
– micromechanical and nanoretential – the connection of liquid fraction of composite or adhesive system with hard tooth tissues at the level of micro- and nanospaces.

Adhesive coupling can be achieved both through direct contact of material with hard tooth tissues and through the use of special adhesive (bonding) systems (from the English ***“bond”*** – connection). Currently, use of adhesive systems is a mandatory technological step in the filling of composite materials.

Properties that should be present in modern adhesive systems (Borisenko A.V. and all, 2009):

– a significant force of connection with hard tooth tissues, which prevents separation of the composite from them during its polymerization;
– durability of formed strong bond with hard tooth tissues;
– preservation of integrity of the marginal fit of filling material to hard tooth-tissues (primarily to the enamel) for a long time;
– good biocompatibility (especially with the pulp of tooth);
– caries preventive action (the ability to prevent development of the secondary caries);
– preservation of properties during long-term storage (long shelf life);
– ease and simplicity of clinical application;
– universatility, compatibility with a wide range of filling materials;
– no toxic and sensitizing effects on the body;
– reliable sealing of dentin tubes (tubules) and isolation of the pulp from adverse effects of filling material.

Existing bond systems can be divided into:

– adhesives to enamel;
– adhesives to dentin;
– multipurpose – to enamel and dentin.

Enamel adhesives. Acid etching, first proposed by Buonocore M. G. (1955), is nec- essary to ensure the adhesion of composite to enamel. Under ac- tion of acid, the peripheral and central zones of enamel prisms are selectively dissolved, and the enamel surface resembles a honeycomb under an electron microscope (Fig. 5.38). For acid etching of enamel the 35–37 % solution or gel of phosphoric acid (Fig. 5.39) can be used. Use of the gel in clinical practice is convenient, because its color (blue, purple or green) makes it possible to control the qual- ity of application and removal, prevent the connection of acid with oral mucosa orskin. At the same time, liquid mordants better penetrate into pits and fissures of enamel. It should be remembered that organic formations on teeth (plaque, pelicle) impede the access of acid to enamel. Therefore, before working with composites all tooth surfaces should be thoroughly cleaned with special brushes, rubber cups, strips and fluoride-free polishing pastes.

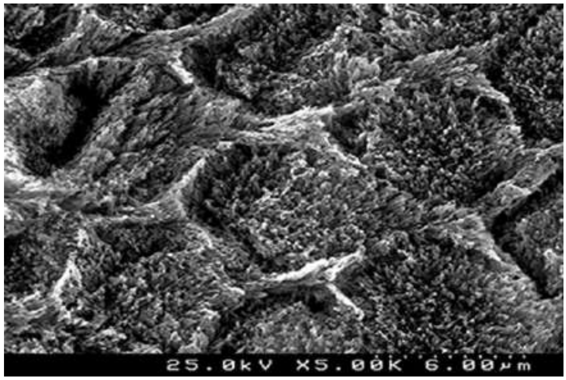


Fig. 5.38. Surface of enamel after acid etching

Fig. 5.39. Etching gel for enamel

The etching time depends on acid resistance of enamel and is 15–30 seconds.

After that, the etching agent is washed off with a water jet for 30–60 seconds (twice time of etching), the enamel surface is dried with an air jet. Properly etched enamel loses its gloss, becomes matte, chalky. If there are no such changes, the etching step must be repeated. Connection of saliva or blood with the etched surface of enamel is unacceptable. If this happens, the etching step should be repeated. It is forbidden to treat the etched surface with alcohol, probe it with an instrument.

As a result of acid etching of enamel the layer with depth of 10–15 microns is completely removed from its surface, the porous surface of enamel with depth to 50 microns is formed. Due to this, the surface of active adhesion of enamel with composite increases, the possibility of penetration of hydrophobic adhesives into the surface layer of enamel is created.

Unfilled or moderately filled mixtures of diacrylates, chemically similar to the polymer matrix of composites, are used as enamel adhesives. Due to high vis- cosity, they slowly penetrate into the thickness of etched enamel. It should be remembered that enamel adhesives are hydrophobic, so before applying them, the enamel surface should be thoroughly dried. After polymerization of an adhe- sive, polymer processes are formed in the interprismatic areas of enamel, which mechanically penetrate into enamel and provide microretential adhesion of com- posite to the enamel surface. The enamel adhesive forms a chemical bond with the composite. The enamel adhesives have no adhesion to dentin, so during filling all dentin should be covered with an insulating liner.

Dentin adhesives (primers) – hydrophilic (that is, compatible with water), are applied to the moistened surface of dentin, which contains a significant amount of organic substances.

Boyd A. and co-authors (1963) were the first to inform about the existence of a layer of enamel-dentin dust formed on the prepared surface of tooth and consisting of tiny (0.5–5 microns) microcrystalline particles of its hard tissues. To define this layer, the authors proposed the term “smear layer”, that is, “smeared layer”. The thickness of this layer is 1–2 microns, it is firmly attached to dentin, but part of the enamel-dentin dust is pushed into dentin tubules, forming a kind of cork 1–5 microns long. During traditional treatment of the prepared cavity and its filling, filling material is fixed through the smear layer, but the adhesion force is insufficient in this case.

Currently, there are three approaches to solve the problem of “smear layer”, determining the mechanisms of adhesion of adhesive systems with dentin surface (Borysenko A.V., 2011; Kazakova R.V., 2018).

1. The adhesion of composite to the dentin surface is achieved by preserving and impregnating “smear layer” with adhesive. When applying this method the “smear layer” is impregnated with hydrophilic low-viscosity monomers. Thus, it is strengthened and becomes a link between dentin and composite. The disadvantage of these adhesive systems is shallow penetration into “smear layer” and as a consequence – insufficient adhesion force.
2. The adhesion of composite to dentin surface is achieved by dissolution and removal of the “smear layer” and surface decalcification of dentin. This technique involves total etching of hard tissues of tooth. As a result of etch- ing the dentin surface with acid, the “smear layer” is completely dissolved and removed. The dentin tubules are opened, the surface layer of dentin is demineralized, the collagen fibers of peritubular dentin are exposed. Hy- drophilic components of adhesive system penetrate into open dentin tu- bules, impregnate demineralized surface layer of dentin

and get bound to the exposed collagen fibers of dentin, forming a hybrid layer that provides a strong bond of composite with hard tissues of tooth. The disadvantage of adhesive systems of this type is wide exposure of the holes of dentine tubules, which increases risk of microbial invasion and can cause compli- cations after filling.

3. Adhesion of composite to the dentin surface is achieved by transformation of "smear layer". This mechanism is carried out by use of so-called "self-etch- ing" primers and adhesives. They are composed of hydrophilic monomers and acids (maleic, esters of phosphoric acid, etc.). When such adhesive acts on dentin the "smear layer" dissolves, the surface layer of dentin is partially demineralized and impregnated with hydrophilic monomers. Thus, dentin etching and impregnation with monomers occurs simultaneously, while "smear layer" is not washed off, but dissolved, it transforms and integrates into the hybrid layer.

In historical aspect, several generations of adhesive systems are distinguished according to the time of creation.

First generation bonding system was characterized by the formation of ionic and chelation bonds with inorganic components of dentin, primarily calcium.But they had low bond strength, in the order of 2 to 3 MPa.

Second generation bonding system included adhesives to enamel and dentin, consisting of modified unfilled "Bis-GMA" (for enamel) and halophosphoric ether "Bis-GMA" (for dentin). It was believed that they impregnate the smear layer, and adhesion occurs due to ionic adhesion of calcium dentin with phosphate groups of polymer component of adhesive. In these adhesives the adhesive bond strength with dentin was low – 4–6 MPa, so composite material was detached from dentin in the polymerization process.

Third generation bonding system used a "smear layer" to attach the composite to dentin, modifying it. They consisted of three successive components: acid as a conditioner for dentin, which modifies or partially removes the "smear layer", hydrophilic organic primer and polymer adhesive. For acid etching (conditioning) of dentin, mainly organic acids (maleic, citric, EDTA) or 10 % solution of phosphoric acid were used for the purpose of careful treatment of dentin and prevention of possible complications in the pulp. The composition of hydrophilic primers for dentin included hydroxyethylene methacrylate (HEMA) and other substances. The primer strands formed during polymerization penetrate into dentin tubules, providing a micromechanical adhesion resembling a compound of adhesive with etched enamel. The adhesion force reaches 15–18 MPa, which is almost equal to the strength of the connection of composite with etched enamel. The first adhesive of this generation, which was widely used, was "GLUMA".

In case of using the adhesive systems of next generation, the "smear layer" is dissolved by acid and removed completely, widely opening the holes of dentine tubules. The latter acquire a funnel shape, which facilitates the penetration of adhesive system into dentin and provides retention of composite material. Nakabayashi (1982) was the first to describe the mechanism of dentin-polymer-hybrid layer formation, which is now widely recognized. In the process of conditioning of dentin, minerals (apatite) are removed from its surface, but the net of naked collagen fibers remains. Hydrophilic primers penetrate into this net and fix dentin fibers in the polymer matrix during polymerization. Thus, a polymer-reinforced layer of dentin is formed, called the "hybrid layer". Specially created for such treatment of den- tin adhesive substances are called "**primers**". Treatment of dentin surface with a primer contributes to its deep penetration into dentin tubules with preservation of intact collagen fibers. With proper primer treatment, the water on dentin surface will be replaced with resin (the primer itself).

Having properties of hydrophobic substance, the primer requires a certain time to penetrate into the thickness of dentin. Therefore, after application it is rubbed into the dentin surface for about 20–30 s. Due to deep penetration of primer into dentin tubules, the special kind of very strong mechanical bond of composite with dentin appears. It is sometimes called not even micromechanical bond (microretention), but nanoretention. One of the important mechanisms of this connection is connection of primer resins and collagen fibers on dentin surface.

In modern therapeutic dentistry, when filling carious cavities with composite filling materials, mainly adhesive systems of the 4th, 5th and 6th generations are used.

Fourth generation bonding system– systems providing formation of the hybrid layer. They contain PENTA – dipentaeritrol pentacrylate ester of phosphoric acid (or dipentaeritrol pentacrylate monophosphate), as well as dimethacrylates such as TGDMA-triethylene glycol-dimethacrylates, UDMA – urethandimethacrylates, etc. with a lower molecular weight. For better penetration of primers into dentin tubules, organic solvents such as acetone and alcohols, which are good carriers for acrylates, were introduced into their composition. They dissolve some organic substances of dentin and create conditions for micromechanical adhesion of the adhesive system in dentin tubules.

To give adhesive system the necessary elasticity, elastomer resins were intro- duced into its composition, whose long, sinuous molecules prevent the separation of composite from the adhesive system during polymerization.

The 4th generation adhesive systems typically contain three components:

- etching gel – 37 % phosphoric acid in the form of gel for etching enamel and dentin;
- primer – a mixture of hydrophilic monomers penetrating the moistened dentin and forming a hybrid layer;

– adhesive is an unfilled resin that provides a bond between composite and hybrid layer and the tooth enamel.

The 4th generation adhesive systems provide a ***three-stage technique*** of appli- cation.

1. Etching. The peculiarity of application of these adhesive systems is acid etch- ing of dentin and enamel – ***total etching technique.*** Exposure of etching gel is recommended: on enamel – not less than for 15 s (15–30 s) , on dentin – not more than for 15 s (half of the enamel etching time). After etching, the carious cavity is washed with water for 30–60 seconds. Enamel is dried with air to a white matte surface, and the dentin is dried with a jet of air reflected from the enamel and left slightly moistened (shiny).

2. Application of primer. The primer is applied to etched dentin on 20–30 sec- onds to penetrate deeply into dentin tubes. To improve diffusion it is advisable to gently rub the primer into dentin surface with an applicator. Then the primer is dried with a weak air jet for 5 seconds. The surface of dentin should acquire a glossy appearance. Getting primer on enamel will not influence the strength of adhesion.

3. Application of adhesive. A thin layer of adhesive is applied to the etched and primed surfaces of carious cavity, including the insulating cap. Reduce the thick- ness of the layer using a weak jet of air or applying it with a brush. When thick layer of adhesive is formed, there is an optical effect of a white line along the edge of restoration, and in a long term – the violation of marginal fit of filling. The ad- hesive is polymerized using a photopolymer lamp (for 10 s) (Fig. 5.40).

Advantages of the 4th generation dentin bonding systems:

– these systems are multi-purpose, provide a strong connection of compos- ite material not only with enamel and dentin, but also with metal, porce- lain, GIC, compomer; provide the greatest adhesion strength (more than 30 MPa); still remain the "gold standard" of dental adhesives;

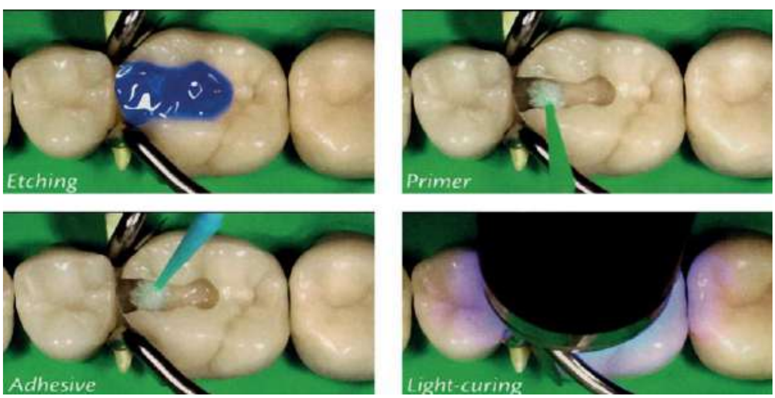


Fig. 5.40. *Stages of work with fourth generation bonding system*

– they provide microretention due to formation of the hybrid zone. In this case, a significant strength of bond of composite with dentin is achieved, comparable to the strength of enamel-dentin compound.

Disadvantages of the 4th generation dentin bonding systems:

– need for the total etching technique of hard tooth tissues;
– presence of several components in the system;
– complexity (multi-stage) applications;
– relatively long time required for application.

The most common representatives of the 4th generation adhesive systems: “All-Bond 2” (Bisco, USA), “Scotch Bond Multipurpose” (3M ESPE, USA), “Syntac” (Vivadent, Germany), “OptiBond FL” (Kerr, USA), “Solobond Plus” (VOCO, Germany) and others (Fig. 5.41).

Fifth generation bonding systems are single-component systems consisting of primer and adhesive in one bottle. They contain components necessary for the formation of a hybrid layer, and for the connection of this layer with composite material. The chemical composition is the mixture of special low molecular hydrophilic resins and elastomers dissolved in water, alcohol or acetone.

The 5th generation of adhesive systems provides ***two-stage technique*** of appli- cation.

1. Etching. It provides for the technique of total etching of hard tooth tissues. If 37 % phosphoric acid is used, the “smear layer” is removed completely and in future the mechanism of adhesion of composite with dentin occurs by forming a hybrid layer. Etching technique is the same as with 4th generation adhesive.

If self-etching (indelible) primers containing a mixture of weak organic acids (most often maleic and HEMA in aqueous solution) are used for dentin conditioning, the adhesion of composite to dentin occurs through transformed “smear layer” that integrates into the hybrid zone. The self-etching primer is rubbed into

Fig. 5.41. *Fourth generation bonding systems (etching gel, primer, adhesive)*

the bottom and walls of carious cavity using an applicator for 20–30 seconds and, without washing off with water, dried with air.

2. Application of one-component adhesive. One-component adhesive is applied to etched dentin, enamel, cap and maintained for 20–30 seconds to penetrate deep. To improve the penetration of adhesive into dentin it is recommended to rub it into the walls of carious cavities lightly with an applicator or carry out dou- ble application of adhesive. The adhesive is dried with weak stream of air until the surface becomes glossy. Then its polymerization is carried out with photopolymer lamp for 10 s.

The 5th generation adhesive systems, containing adhesive and primer in one bottle, are: "Prime & Bond 2.0", "Prime & Bond 2.1", "Prime & Bond NT", "XP Bond" (Dentsply, UK) (Fig. 5.42), "One Step" (Bisco, USA), "Adper Single Bond 1, 2" (3M ESPE, USA), "Optibond Solo", "Optibond Solo Plus" (Kerr, USA), "Solo- bond M", "Admira Bond"(VOCO, Germany), etc. In some of these adhesives there are additionally introduced substances that have anti-carious effect due to release of fluoride, for example, cetylamine hydrofluoride in "Prime & Bond 2.0" (Dentsply, UK).

The adhesive systems containing conditioner and primer (self-etching primer) in one bottle are: "Prime and Bond NT + NRC" (Dentsply, UK), "Optibond Solo Plus SE" (Kerr, USA), "AdheSE" (Vivadent, Switherland).

Sixth generation bonding system – one-step self-etching adhesives. These include "Adper Prompt L-Pop", "Adper Prompt" (3M ESPE, USA), "Xeno III" (Dentsply, UK), "Etch and Prime 3.0" (Degussa, Germany), "Clearfil Se-Bond" (Kuraray, Japan), etc. The 6th generation adhesive systems are produced in the form of two preparations, mixing of which is carried out immediately before use; an active solution is obtained – self-etching and priming adhesive. The adhesive systems of 6th generation do not require separate stages of etching of hard tooth tissues, since the acidic components necessary for etching are contained in their compo- sition. In this regard, the technique of application of such adhesives is ***one-stage***.

Fig. 5.42. *Fifth generation bonding system*

The composition of 6th generation adhesive sys- tem (two-component) by the example of "Adper Prompt L-Pop" (3M ESPE, USA):

– bottle No.1 – methacrylate of phosphoric acid ether, initiators, stabilizers;
– bottle No. 2 – water, fluoride compounds, sta- bilizers.

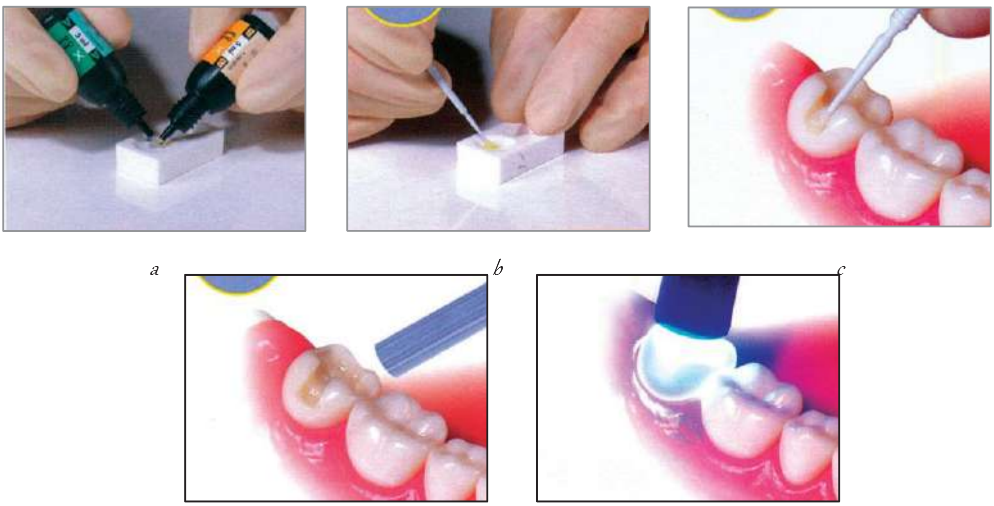
The adhesive is ready for use after mixing two components.

Technique of applying of 6th generation adhesive systems involves applying the mixture of two components to the prepared clean carious cavity for 20–30 s. After that, the adhesive film is carefully dried with an air jet for 4–5 s. The surface should be shiny. Adhesive is polymerized for 10 seconds using a photopolymer lamp (Fig. 5.43).

Clinical benefits of one-step adhesives:

– minimum possible error (due to minimum number of steps);
– absence of etching, washing, drying stages, and therefore it reduces the operating time;
– they provide good initial and long-term strength of the connection (nanoretention) with enamel and dentin without etching: the adhesion force to dentin is 18–23 MPa;
– acetone-free, hydrophilic;
– they minimize the occurrence of postoperative sensitivity (due to qualitatively polymerized hybrid layer);
– compatible with a wide range of restoration materials, compomers.

Sevens generation boding systems – one-step one-component self-etching adhesives (self-etching all-in-one adhesives), combining the etching of hard tissues, processing them with primer and adhesive in one procedure. The 7th generation adhesive system includes: “i-Bond” (Heraeus Kulzer, Germany), “Xeno V” (Dentsply, USA), “Clearfil S3 Bond” (Kuraray, Japan).



a *b* *c*

d *e*

Fig. 5.43. *Stages of application of the sixth generation bonding system:*

a, b – mixing of the components; c – application on the bottom and walls of carious cavity;

d – even distribution of adhesive by means of an air jet;

e – polymerization of adhesive for 10 seconds

Technique of applying the adhesive i-Bond. Consistently apply a minimum of 3 layers of adhesive on the entire surface of carious cavity. During the next 30 sec- onds, gently rub adhesive into hard tissues of tooth. The surface should be shiny. Using a soft air supply at an angle to the cavity, distribute it and dry for a few seconds. Polymerization lasts for 20 seconds.

Clinical benefits of the 7th generation adhesive system:

– easy to use, it saves time (one-component product in one bottle);
– there is no process of mixing;
– the bond strength to dentin is equal to 18–25 MPa;
– it includes the active ingredient Gluma Desensitizer, due to which it does not cause hypersensitivity;
– it does not lead to excessive moisture or drying of carious cavity;
– adhesion force with both dentin and enamel is the same.

The comparative characteristic of modern adhesive systems is given in table 5.1.

The adhesive systems of 6th and 7th generations are the most convenient for use in pediatric therapeutic dentistry, where safe adhesion during maturation of dental tissues, simplicity and speed of manipulation are especially important.

Table 5.1. Comparative characteristics of modern dentin bonding systems

Generation of adhesive	Number of components	Number of work phase	Etching	Application of the primer	Application of the adhesiv	Representatives
Dentin bonding systems						
4th	Multi-component	3	+	+	+	"Pro Bond" (Dentsply), "Scotchbond MP Plus" (3M), "Syntac" (Vivadent), "Optibond"
5th	Single-component	2	+	+		"Prime & Bond 2.0", "Prime & Bond 2.1" (Dentsply), "One Step" (Bisco), "Single Bond" (3M)
6th	Multi-component	1	+			"Adper Prompt L-Pop", "Adper Prompt" (3M ESPE), "Xeno III" (Dentsply), "Contax" (DMG, Germany), Clearfil Se Bond"
7th	Single-component	1	+			"I-Bond" (Heraeus Kulzer), "Xeno V" (Dentsply)
8th	Single-	1	+			G-Premo Bond (GC)

Nanofilled bonding agents (the 8th gen- eration bonding systems) – are one-step ad- hesives.

The use nanosize fillers increases penetra-tion of resin monomers and the hybrid lay-er thickness. They are capable of producing bond strengths of over 30 MPa (Fig. 5.44). After application, the adhesive is dried with the strongest possible air flow. Exposure 10 seconds.

Fig. 5.44. *Eighth generation bonding system*

Classification of bonding systems by clinical step is presented in Fig. 5.45.

Classification of l bonding systems by adhesive strategy is presented in Fig. 5.46.

Universal adhesives can be used under different bonding strategies, adapting the most appropriate to each specific clinical situation (Fig. 5.47).

Technique of tooth restoration using self-curing composite materials

1. Professional hygiene of all surfaces of tooth, which will be filled, and teeth located nearby (removal of plaque with round brushes fixed in micromo- tor or angular handpiece, rubber cups, pastes intended for professional hy- giene, but not containing fluoride).
2. Selection of the shade of filling material.

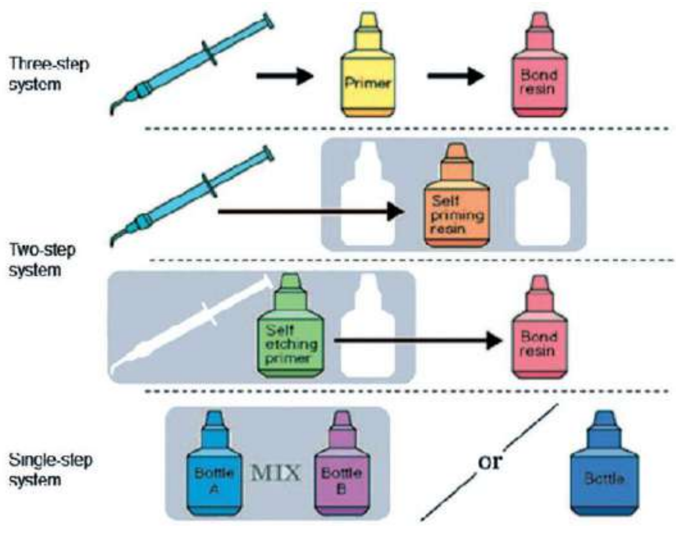


Fig. 5.45. *Classification of bonding systems by clinical steps*

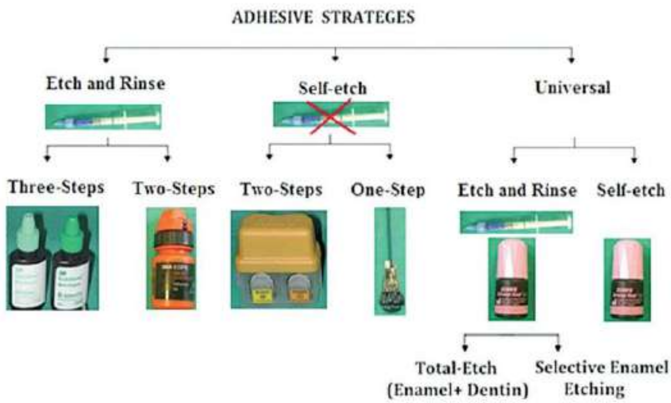


Fig. 5.46. *Classification of bonding systems by adhesive strategy*

Fig. 5.47. *Universal bonding systems*

3. Preparation of carious cavity.
4. Isolation of tooth from saliva.
5. Washing and drying of the carious cavity.
6. Imposition of insulating liner (if it necessary, a pulp cap).
7. Etching of enamel: etch the enamel for 15–30 seconds, wash off the etching gel or liquid with water for 30–60 seconds, dry. The etched surface becomes chalky, matte, loses its gloss.
8. Application of adhesive (a thin layer with brush on the etched enamel surface and cap).
9. Introduction of composite filling material into the carious cavity in one or two portions.
10. Final treatment of the filling (after complete setting of material). Grinding and polishing of the filling with diamond heads and finishing drills, special kits of abrasive tools and abrasive pastes. Approximal surfaces are treated with strips of different abrasiveness.

11. Fluoridation of enamel areas adjacent to the filling. The aim is to increase mineralization of enamel adjacent to the filling, including demineralized one in the process of acid etching . To do this, use an application of fluoride gels, varnishes, solutions. In the case of postbonding, this stage is no longer necessary.

Technique of tooth restoration using light curing composite materials

1. Professional hygiene of all surfaces of tooth, which will be filled, and teeth located nearby (removal of plaque with round brushes fixed in a micro- motor or angular handpiece, rubber cups, pastes intended for professional hygiene, but not containing fluoride).
2. Selection of shades of filling material (using Vita Color scale). The surfaces of tooth and scale should be moistened. Color selection should be carried out in daylight (natural) light.
3. Preparation of the carious cavity.
4. Etching of enamel and dentin (an extremely important stage, since mistakes made in the process of etching can lead to development of complications). The etching time is 30 seconds. The etching gel is first applied to enamel, and after 15 seconds – to dentin. If self-etching adhesive systems are used, the etching step is not carried out.
5. Washing off the etching gel with water for 45–60 seconds. The strength of jet should be moderate.
6. Drying of the carious cavity (very carefully, so as not to damage the surface of etched dentin). The air jet is directed at the enamel at an angle to avoid overdrying of dentin.
7. Application of adhesive system (features of work with adhesive systems of different generations are described above).
8. Introduction of composite. The filling mass is introduced into carious cavity with carvers and pluggers, preferably with a teflon or titanium coating. The thickness of each layer of composite should not exceed 1.5–2 mm. Layer-by-layer composite application technique allows to achieve maximum polymerization and reduction of polymerization shrinkage. When illumi- nating the composite, it should be polymerized through enamel or through previously introduced layers of composite in order to maximize “welding” of the composite to enamel or to adjacent layers (“vectorial polymeriza- tion” technique). The second illumination is carried out perpendicular to the surface of composite. It should be remembered that the shrinkage of material is directed to the light source.

9. Postbonding is the application of enamel adhesive to the formed and polymerized filling in order to eliminate microspaces between filling and enamel, as well as possible microcracks on the surface of composite.
10. Grinding and polishing of the composite filling (in order to give it final shape and gloss of natural enamel). The diamond heads with a thin diamond coating, carborundum finishing drills are used, for aproximal surfaces – strips and dental floss.

The final stage is polishing of the filling with special polishing heads of dif- ferent shapes for composites and polishing pastes included into the material set.

When working with photopolymer materials, observe the rules that help to reduce the polymerization shrinkage of material:

- use an adequate light source with the wave length of 450–500 nm for polymerization;
- if possible, direct light source from the opposite side of filling material, carry out the starting illumination through enamel;
- observe polymerization time of each layer according to the recommendations (it should be remembered that dark colors polymerize longer than light ones);
- the light source should be as close as possible to the surface of filling mate- rial;
- when working with a halogen lamp, observe the safety rules: wear safety glasses and protective screen;
- after completion of the filling, carry out the final (finishing) illumination of material. In particular, the final polymerization is carried out in cavities of classes I and V respectively from occlusal and vestibular surfaces, in the cavities of classes II, III, IV – from vestibular, oral and occlusal surfaces.

When working with light curing composite materials, it should be remembered that it is possible to restore the natural shade and transparency of tooth, if it is necessary to use opaque shades. It is generally accepted that the lost dentin is replaced by opaque shades of composite. During restoration of the lost enamel consider distinctions of color shades of body, neck and incisal edge of a tooth. The incisal edge tends to have lighter shade and greater transparency than the crown body. The neck of tooth usually has darker and yellowish shades.

Technique of tooth restoration with compomers

1. Professional hygiene of all surfaces of tooth, which will be filled, and teeth located nearby (removal of plaque with round brushes fixed in a

micromotor or angular handpiece, rubber cups, pastes intended for professional hygiene).

2. Choice of shades of filling material is carried out using the Vita Color scale. In this case, the surfaces of tooth and scale should be moistened, the color selec- tion should be carried out in daylight (natural) light.
3. Washing and drying of the carious cavity.
4. Application of adhesive system (preferably self-etching).
5. Application of a compomer. The filling mass is introduced into carious cavity with carvers and pluggers, preferably with teflon or titanium coating. The thickness of each layer of compomer can reach 2–4 mm.
6. Polymerization of the material is done for 20–40 seconds (depending on shade) using a light curing unit.
7. Postbonding is the application of enamel adhesive to formed and polymerized filling in order to eliminate microspaces between filling and enamel, as well as possible microcracks on the surface of compomer.
8. Grinding and polishing of the compomer filling (in order to give it the final shape and gloss of natural enamel). For this purpose diamond heads with a thin diamond coating, carborundum finishing drills are used, for approximal surfaces – strips and floss. Polishing is carried out with special polishing heads of different shapes and polishing pastes.

Control questions to subsection "Composite filling materials"

1. Describe the main components of composite filling materials.
2. Name the classifications of composite filling materials (according to filler particle size, polymerization mechanism, consistency, etc.).
3. What are advantages, disadvantages and indications for use of macro- and microfilled composite materials?
4. What are advantages, disadvantages and indications for use of compomer materials in pediatric dentistry?
5. Name advantages, disadvantages and indications for use of hybrid composite materials.
6. Describe modern bonding systems. What are advantages and disadvantages of bonding systems of the 4th, 5th, 6th, 7th and 8th generations?
7. What are the approaches to solve problem of "smear layer" that determine the mechanism of adhesion of bonding systems with dentin?
8. Describe the main stages of filling a carious cavity using self-curing com- posite material.
9. Describe the main stages of filling a carious cavity using light curing com- posite material.
10. Describe the main stages of filling the carious cavity using a compomer.

Test tasks to subsection " Composite filling materials"

1. **In 14-year-old child the carious cavity located on mesial contact surface of the 21 tooth was found. What material is most expedient for its permanent filling?**

A. Composite material B. Compomer C. Silver amalgam
D. Polycarboxylate cement E. Glass ionomer cement

2. **During preventive examination of a 4-year-old child, dentist found the carious cavity on occlusal surface of the 51 tooth. What material should be used for its permanent filling?**

A. Polycarboxylate cement
B. Compomer material
C. Light curing composite
D. Self curing composite
E. Phenolate cement

3. **A dental examination of 15-year-old child revealed the carious cavity on distal contact surface of thw 25 tooth. What material is most expedient for its permanent filling?**

A. Polycarboxylate cement
B. Compomer material
C. Light curing composite
D. Self curing composite
E. Phenolate cement

4. **In 16-year-old teenager the carious cavity was found in the precervical region on vestibular surface of the 45 tooth. What material is most expedient for its permanent filling?**

A. Compomer material
B. Silver amalgam
C. Phenolate cement
D. Silicate cement
E. Chelate cement

5. **Dentist chose a composite material for permanent filling of I class carious cavity in the 36 tooth. What component of its composition determines its mechanical strength?**

A. Organic matrix
B. Inorganic filler
C. Polymerization inhibitor
D. Catalyst
E. Dyes and pigments

6. **During restoration of the 12 tooth, dentist used the multicomponent bonding system, which provides for three-stage technique of application – etching, primer application, adhesive application. What generation of bonding systems does this system belong to?**

A. IV B. V C. VI D. VII E. VIII

7. **In 14-year-old child for filling the carious cavity in 11 tooth the light curing composite material with bonding system of two-step application technique was chosen: etching and application of one- component adhesive. What generation of bonding**

systems does this system belong to?

A. IV B. V C. VI D. VII E. VIII

8. In 15-year-old teenager, the single – component adhesive system was used during restoration of the 22 teeth, for which the etching, primer and adhesive stages are combined into one procedure. What generation of bonding systems does this system belong to?

A. IV B. V C. VI D. VII E. VIII

9. When working with the light curing composite materials, it is necessary to consider the recommendations which help to reduce polymerization shrinkage of material. One of these recommendations is the use of adequate source of light polymerization with the wave length of:

A. 450–500 nm B. 300–400 nm C. 100–200 nm D. 50–100 nm E. 200–300 nm

10. *For filling the carious cavity in 25 tooth, dentist chose the light curing composite material. What should be the optimal thickness of each layer of material, consistently introduced into carious cavity?*

A. 0.5–1 mm B. 1.5–2 mm C. 3–4 mm D. 5–6 mm E. 8-10 mm

Correct answers to test tasks

1.– A	2.– B	3.– C	4.– A	5.– B
6.– A	7.– B	8.– D	9.– A	10.– B

CURING LAMPS

Polymerization of the composite filling materials occurs by connecting monomers with each other using oxygen ions and free radicals. The reaction occurs under influence of the initiator polymerization system. For the formation of free radicals in composite filling materials of photopolymerization, camphorquinone is used, forming unstable compounds with tertiary amines. Under the action of light, these compounds undergo photofragmentation to form free radicals. To ensure the light polymerization of composite filling materials, special light sources are used — the light curing units — devices that emit blue light of high-intensity with the wave length of 400–500 nm. The maximum radiation occurs at the wave length of 470 nm. The light source should be powerful – 300–1000 mW/cm^2.

The main components of the light curing unit are light source and light guide. Depending on the light source, modern light curing units are divided into: tungsten-quartz halogen curing unit (TQH), plasma arc curing (PAC), argon laser curing unit and light emitting diode (LED) unit.

Tungsten-Qartz Halogen Curing Units (TQH)

Tungsten-quartz halogen curing units (TQH) have been widely used in dental practice for 25 years (Fig. 5.48).

The devices generate light by heat- ing the incandescent filament using the energy of electric current. The spec- tral emission of filtered quartz-tung- sten-halogen emitter coincides with absorption curve of most camphoro- quinone-based photo absorbers. The production capacity of halogen lamps is quite high. Therefore, in this spectral range, the light emission is sufficient- ly intense

for polymerization of resto-
ration materials within a short period

Fig. 5.48. *Halogen curing unit*

of time. Optical fiber light guides of halogen devices have the marked conicity, which allows to accumulate light energy and transfer it to a smaller field in order to increase the intensity of the light flux. Most of the electricity is dissipated as heat. Light filter lets in only "useful" blue light with the wave length of 400–500 nm. Light energy, "unnecessary" for photopolymerization, is cut off. Thus, the useful energy yield of a halogen-activated device is approximately 0.7 %.

The disadvantage of halogen devices is primarily the insufficient radiant efficiency. As a result, wide spectral range of radiation is formed – from dark infrared to intensely ultraviolet sections of the electromagnetic spectrum. This means that the radiation of halogen devices must be well filtered, since only a relatively small percentage of the spectral emission is used for polymerization of restoration materials. The halogen lamp emits a significant amount of infrared rays, gener- ates large amount of heat, which can lead to overheating of a tooth, so the halogen source must be intensively cooled by such part of the device as a fan. Another dis- advantage of quartz tungsten halogen technology is the low reliability of the lamp and filter. The lamps wear out over time, as a result of which the radiation power gradually decreases. Without constant power measurement, it is impossible to determine whether it is sufficient for the complete polymerization of restoration material. Check the power of luminous flux of the lamp once a week. In addition, the filters are subjected to considerable heat and can fail. If this occurs, the waves of unwanted length can negatively affect the vision of patient, doctor, assistant. The halogen dental device can be replaced not when it fails, but when the control device detects decrease in the radiation intensity below limit allowed for full po- lymerization of material (300 mW/cm^2). In order to control the intensity of light flux radiometers are used. They can be separate devices ("Photon", "Demetron"), and mounted in body of the light curing unit ("Luxdent", "Bluedent").

Halogen curing units with Softstart function ("Luxdent-001", "Degulux soft- start"). This is the mode of operation of light curing unit, when the maximum luminous flux is achieved gradually, after a certain period of time. The polym- erization algorithm in the "soft start" mode is as follows: the power of luminous flux is 50–60 % for the first 10 seconds, and then it increases to 100 %. This mode reduces the consequences of "polymerization stress": it reduces the shrinkage of composite and increases the strength of its adhesion to the hard tooth tissues.

Halogen curing units for pulsating-distant light polymerization technique are also designed to delay the achievement of final polymerization of composite. When carrying out the technique of pulsating-distant photopolymerization technique, different modes of light emission are used. First, the material is irradiated with light of 1/3 of the required power (200 mW/cm^2) for 3 seconds, that is, in the first stage, the material receives about 10 % of light energy required for polym- erization. This amount of light energy triggers the polymerization reaction, provides sufficient processing strength of the surface layer of material. However, the composite does not reach the final polymerization, maintaining sufficient fluidity. Then comes the “dark” period of 3–5 minutes. During this period, due to the re- sidual fluidity of material, the stresses resulting from polymerization shrinkage are compensated. At this stage, the surface of filling is ground and polished. Then, the final polymerization is carried out with light flux of full power (600 mW /cm^2) during time recommended by the manufacturer of filling material. The technique of pulsing-distant photopolymerization is used mainly in polymerization of the top layer of filling, which contacts the tooth enamel. This principle is implement- ed in the light curing unit “VIP junior” (Bisco).

Due to above-mentioned disadvantages of halogen devices, other sources of radiation of the visible spectrum have been developed.

Plasma Arc Curing (PAC) Unit

White light is generated during operation of plasma-arc dental devices. After passing through the light filter, it turns into the blue light with wave length of 400–500 nm.

In plasma-arc technology, an electric current passes between two electrodes, forming high-energy form of matter called plasma. The emission of radiation in these systems is very intense. The wave length of such radiation cannot be used with camphoroquinone-based initiation system. To control the light emission of plasma-arc lamp, light filtration and cooling are necessary.

The maximum diameter of the light beam in plasma-arc devices is 5 mm.

The *positive properties* of plasma-arc lamps is that they emit very intense light flux, resulting in the decrease of polymerization time of composite materials. Po- lymerization of a portion of the composite material is 5–10 s, fissure sealant – 4–5 s, in contrast to 20–40 s required for their polymerization with the halogen cur- ing lamp.

Disadvantages of plasma-arc dental devices are their high cost and significant operating costs. In addition, the band of filtered wave frequencies of 400–500 nm coincides with a similar indicator of halogen lamps. When using photopolymer materials that require long-term exposure for complete polymerization, signifi- cant accumulation of heat in the tooth cavity is possible, which causes its over- heating. In order to reduce unwanted effects, accumulation of heat in the lamp itself, the discharges should be broken down into short flashes of 3–5 s, with inter- vals between them for cooling. Therefore, if many cycles are required for polym- erization, the advantage of using a high intensity light flux is reduced. In addition, plasma-arc devices require significant electrical power, which makes it impossible to create a wireless device.

Laser (argon laser) curing unit

The electrical energy in the laser is directly transformed into continuous ray of light. The two most intense waves produced by the argon laser are 514 nm (green) and 488 nm (blue). Technological requirements for laser filtration mirrors determine the use of light flux with the wave length of only 488 nm, which is located inside the area of spectral absorption of camphoroquinone and is able to initiate the polymerization reaction of composite material.

The main *advantage* of argon lasers as devices for the polymerization of dental materials is that they have high, although very narrow, wave length distribution. Therefore, photons of the argon laser have a similar efficiency in activating the absorption of camforoquinone. The *disadvantages* of these devices are high cost, significant operating costs. They cannot be wireless devices because they require very high power to generate the energy inversion required for the cooling system to function. The main device for laser radiation is quite bulky and non-ergonom- ic when moved during operation. The manual part of device is inconvenient for manipulations in the patient. In addition, when using laser, safety rules must be observed to prevent deflection of the ray, which can damage soft tissues and eyes.

Light Emitting Diode Unit (LED technology)

The first LED devices were created in the early 60s of the last century and emitted light in red, yellow and green ranges. In the last decade, there were light guides that emit light of the blue part of the spectrum.

Only in the last few years, leds with sufficient intensity were created, which made it possible to use them in dental practice.

Advantages of led devices. The wave length range of light emitted by the led is very narrow (blue led generates neither ultraviolet nor infrared radiation). Unlike halogen and plasma-arc devices, these devices can be used without fil- ters. The wave length of the led emitter is about 470 nm, ideally coinciding with the wave length of absorption of camphoroquinone used in most photopolymer dental materials. The range of radiation of the peak intensity is wider than that of laser devices. At the same time, it is narrower compared to the range of the halogen and plasma-arc source, so it coincides more precisely with the absorp- tion spectrum of camforoquinone. All photons of led participate in the initia- tion reaction of polymerization of materials and have the wave range in which camphoroquinone system is most effective. The efficiency of led emitter is about 10 %, for other sources of radiation – less than 1 %. This means that the led lamp generates much less heat than other devices. The manual unit of device can be wireless, powered by a battery. This device is more stable than laser tubes or halogen and plasma-arc devices. The blue led of cold light is used in led light curing units. The advantage of this type of light source is long oper- ating time (about 20 thousand hours) and the lack of effect of thermal ra- diation on the tissues of oral cavity due to the absence of infrared waves. That is why led light curing units are lightweight and compact (Fig. 5.49).

Fig. 5.49. LED dental light curing units

The *disadvantage* of led photopolymerization is considered to be the unsatisfactory level of polymerization of darker shades of composites. To prevent this, light guide matrices of two types are used – for light and dark shades in one light guide, which significantly increases the cost of the light curing unit.

To direct the light flux to a tooth, special light guides of different (1–10 mm) diameters are used. They can be rigid or flexible, and have a diaphragm. During operation, the light guide of lamp should be at the minimum possible distance from the surface of material. It must be handled very carefully: avoid damage to the polished surface, which emits light, and contact of the light guide with filling material, which has not passed the polymerization stage. Contamination of light guide reduces the intensity of light irradiation and, as a consequence, impairs the quality of photopolymerization. If the filling material adheres to polished surface of the light guide, it can be cleaned only in specialized workshops, and not on your own.

For convenience, photopolymer lamps have built-in timers with sound signals, allowing to record the polymerization time (usually it ranges from 20 to 40 seconds).

Fig. 5.50. Protective goggles

The luminous flux of light curing unit contains a significant part of ultraviolet rays, which adversely affect the visual organs of medical workers and patients. This dictates the need to protect the eyes with the help of special devices that perform the function of light filters (caps and screens on the led, shields, goggles, etc.), usually yellow or orange (Fig. 5.50–5.52).

Fig. 5.51. *Use of safety glasses when working with light curing devices*

Light curing units can be integrated into the dental unit, connected in one body with other devices (ultrasonic scaler – “Woodpecker”, UDS-L, etc.) or other light sources (white, green, red – “Luxdent-111”).

Fig. 5.52. *Protective glass and cover for light curing units*

Chapter 6

FILLING OF CARIOUS CAVITIES IN PRIMARY AND PERMANENT TEETH

ISOLATION OF THE OPERATING FIELD IN PEDIATRIC DENTISTRY

Isolation of the operating field is an important stage in treatment caries and its complication in primary and permanent teeth. It provides to keep the operative field dry, includes isolation from saliva, blood, gingival fluids and soft tissues like lips, cheeks, gingiva and tongue, to prevent bacterial contamination and is used both for harm prevention and little patient comfort and operator efficiency.

Developed by Sanford C. Barnum in 1864, the rubber dam is considered the optimal method to isolate a dental operating field and to prevent moisture contamination during the placement of direct restoration and endodontic procedures.

Benefits:

- Absolute tooth isolation (risk of cross-infection to root canal system is reduced) – an obligatory condition during an endodontic treatment and the placement of direct restoration with adhesive materials.
- Dentists and dental assistants are protected against infections, which can be transmitted by patient's saliva.
- Retraction and protection of the soft tissues (gums, tongue, lips, and cheeks), which are sheltered from cutting action of a bur.
- Better visibility in an operating area.
- Patient is protected from the ingestion or aspiration of small instruments, dental fragments, irrigating solutions, or irritant substances.
- Reduced operator time
- Reduces the risk of dehydration of oral tissues.
- Patients are more comfortable, as they do not feel that their mouth is invaded by hands, instruments and liquids, they will not have to rinse their mouth every five minutes, decreased stimulation of the gag reflex.
- Rubber dam reduces child's stress during dental care and can improve co-operation with doctor.

Indications for rubber dam placement are pulpotomy, pulpectomy and all endodontic procedures, composite restorations and fissure sealants in primary and permanent teeth.

Contraindications to use of the rubber dam are a patient's allergy to the chemi- cal constituents of rubber (latex allergy). However, latex-free dam is available and must be used for anyone with known latex allergy, suffer from severe asthma, or have trouble breathing through nose, children with low degree of cooperation.

There are some instances where rubber dam placement is extremely difficult or impractical. These instances include situations, where one is operating on a newly erupted tooth that is unable to retain a clamp, anomaly tooth position, when placed on teeth that are poorly shaped, very damaged teeth and in tight contact with each other. In such cases, treatment should not be undertaken unless the tooth – particularly if damaged – has not been reconstructed to allow easy positioning of the rubber dam.

Rubber dam equipment required for rubber dam placement includes: latex rubber dam sheet (dam), rubber dam frame, rubber dam punch, rubber dam for- ceps, clamps, additional accessories.

Rubber dam sheet is available in different sizes (5" x 5" inches and 6" x 6" inches, as well as rolls), colors (light, blue, black and green), and thicknesses (special heavy – 0,35 mm, extra heavy – 0,30 mm, heavy – 0,25 mm, medium – 0,20 mm, and thin – 0,15 mm). The medium and heavy rubber dam is widely used in pediatric dentistry. Heavy and extra heavy sheets deliver the best retraction of peripheral tissues and it is stretched in different directions to confirm that it does not tear. Different colors and flavors of sheets allows dentist to involve a child to the treatment process (Fig. 6.1).

Rubber dam punches is used to make round holes of different diameters (0,7–2 mm) in rubber sheet, depending on the tooth to be isolated. The working end is designed with a plunger with a sharp end on one side and a wheel on the other side. This wheel has different sized holes on the flat surface. Perforat- ing holes may have different diameters to better it the teeth (Fig. 6.2).

Fig. 6.1. Rubber dam sheet

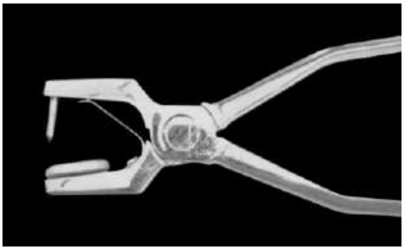


Fig. 6.2. Rubber dam punch

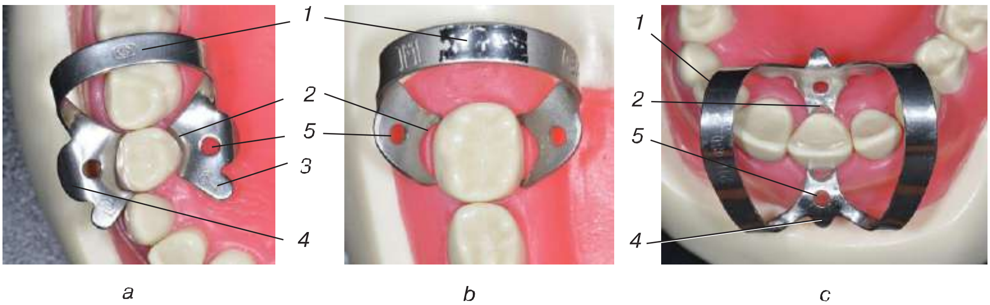


Fig. 6.3. *Dental clamps: winged clamp 64 for first primary molar (a); wingless clamp W8A for permanent molars (b); double bow clamp 211 for anterior teeth(c). Components of clamp: 1 – bow; 2 – jaws; 3 – anterior wings; 4 – central wings; 5 – hole for forceps*

Clamps mainly serve two functions – anchor the rubber dam to the tooth and help in retraction the gingivae. Clamps are available in different sizes and specifically adapt to each group of teeth. They are composed by the bow that connects two horizontal jaws (Fig. 6.3). Those jaws present prongs that grip the tooth cervically below its largest circumference, while the round holes, are used for fitting the forceps. They also present rectangular holes, which allow placing a bold hand instrument for transposing rubber sheet underneath the clamp. Some clamps have wings that allow attaching clamp in the rubber dam, while others are wing- less. Clamps should be placed on the tooth that is more distal on an arch to the tooth in which treatment is to be performed, particularly when isolating posterior teeth. The clamps are classified as winged, wingless and special butterfly-shaped clamps.

Whichever clamp is chosen, it should ideally have a four-point contact at the cervical region of tooth to prevent rocking and/or slips of. If clamp is too large, it will impinge on the soft tissues. If it's too small, it will not grasp the tooth's sur- face and will be unstable. The bow of clamp should be positioned on the distal of tooth.

Clamps are available in different sizes and specifically adapt to each group of teeth. Gingival retraction clamps (. Fig. 7.13a, b) are designed to be used in teeth that are not completely erupted and if lesions are too close to a gingival level. In these clamps, the jaws are directed gingivally to allow anchorage on a more cer- vical region of tooth.

The B1 and U67 are universal retractor for all mandibular molars. The B2 and B3 are paired set of clamps, as the buccal jaw is wider than the lingual jaw, and are recommended for use on maxillary molars. Incidentally, the B2 and B3 are good choices for sealant isolation, as jaws do not impinge on tissue as do a W14A or W8A. For partially erupted tooth, a clamp with subgingivally designed jaws is used, suitable to the size of anchor tooth (W2A, W8A, A12, A13 A14, W14 A).

The most widely used anterior styles are 210, 211, 212, B5, and B 6 (Brinker's gingival retrac- tors). The jaws of B5 and B6 are offset, with the facial jaw ori- ented in an apical direction and the lingual jaw oriented in an occlusal direction. This feature allows these clamps to be seat- ed to the depth of gingival sul- cus without tissue laceration, resulting in excellent access to the cervical lesion.

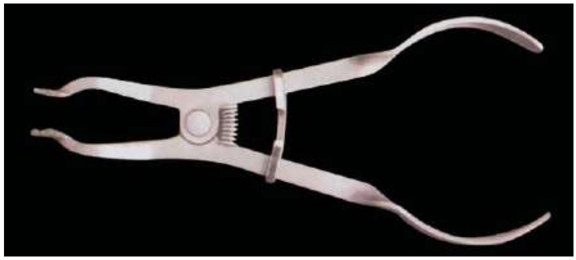


Fig. 6.4. *Rubber dam forceps*

Fig. 6.5. *U-shaped rubber-dam frame*

Rubber dam forceps are used to carry the clamp to the tooth. They are designed to spread the two working ends of the forceps apart when the handles are squeezed together. Working ends have small projections that fit into two corresponding holes on the rubber dam clamps (Fig. 6.4).

Rubber dam frame support the edges of rubber sheet. Rubber sheet must be stretched and fixed on the lateral pins of the frame. Different frame shapes are available. The Young frame has a U-shape with lateral pins used to fix rubber sheet (Fig. 6.5).

The Otsby frame has a hexagonal shape, anatomically projected for better contouring the face of patient, thus allowing some distance between the rubber dam and patient's nose for more comfortable breathing. Rubber dam frames are available in either metal or plastic, plastic frames have advantage of being radio-lucent. There are also frames integrated to the rubber sheet, aiming to simplify placement of rubber dam: these have high flexibility and may reduce the need of clamps (ex. Optradam, "Ivoclar-Vivadent")

Before positioning the rubber dam, a lu¬bricant or petroleum jelly is usually applied on the undersurface of the dam. It is usually helpful when the rubber dam sheet being applied to the teeth. Besides using clamps, the rubber dam can be retained and stabilized using other types of retainers: dental floss ligatures, stabilizing cords, O-rings, and elastic ligatures.

Placement of Rubber Dam

Preparation. First of all, remove plaque by brushing and flossing the teeth. Be- fore positioning the rubber dam, it is a good idea to illustrate to a child utility and function of dam, for exam¬ple, we can place a fingertip in the dam opening. The patients must also be told that, with the dam in place, they may safely swallow, cough, or yawn and that they may do so without placing their hand in front of their mouth! The only things they must not do are talk and rinse.

Involving a child to the process of a rubber dam applying. Give all explanations at a child's level of understanding. Use euphemisms appropriately. A few explan- atory words and reference to the rubber dam as "raincoat" for a tooth or as "Hal- loween mask" help allay child's anxiety. A child who understands the reason is more likely to cooperate (Fig. 6.6).

1. Choose and testing the clamp. The next step is to test a clamp. It is neces- sary to choose the one that best adapts on the anchor tooth. The choice of clamp is simply based on the fit, which depends on the tooth size, location on an arch, and eruption stage of the anchor tooth. The clamp bow must be directed distally to the anchor tooth. For patient safety, a piece of dental floss (about 30 cm long) must be tied on the clamp holes or bow before in- serting it into the mouth to avoid accidental aspiration. It can also be tied on both circular holes of the clamp, increasing a safety in the case it breaks on the region of bow while inside a mouth. (Fig. 6.7).
2. Templates used to mark the rubber dam and dental dam perforation. The rubber sheet must be perforated to adjust properly around the teeth to be isolated. If during treatment procedures, only a single tooth at a time is isolated, you can make just one hole, positioned slightly off-center in the rubber dam sheet. If additional teeth or groups of teeth need to be isolated,

Fig. 6.6. *Involving a child in process of rubber dam applying*

Fig. 6.7. *Dental floss is tied onto clamp before testing*

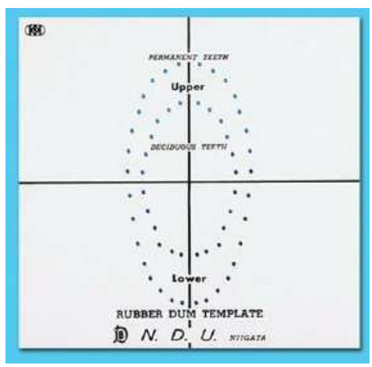


Fig. 6.8. *Template used to mark rubber dam*

templates are available for orientation of the holes. The diameter of perforating hole must be selected according to the cervical diameter of each tooth, generally following the sequence presented in. It is important that the punch can deliver perfect and complete perforations. Incompletely cut perforations easily result in tear of the rubber during manipulation or may lead to penetration of saliva after the rubber dam is in place (Fig. 6.8).

3. Placement of the clamp and the dental dam. Use the forceps to stretch open the clamp in dental dam and position at the cervical region of tooth, it should have a four-point contact (Fig. 6.9). Clamp bow must be directed distally to the anchor tooth. Disengage the forceps and check the clamp is stable, then use a fat plastic or excavator to release the dental dam from the wings.
4. Inverting rubber dam edges. To reduce leakage and obtain an effective seal, rubber dam needs to be inverted into gingival sulcus; this may be simply carried out by blowing air from the 3-in-1 syringe around cervical part of tooth, using a cord-packing instrument or excavator. On the interproximal area, rubber dam must be inverted towards the interproximal papilla using dental floss (Fig. 6.10).
5. The dam is stretched with rubberd dam frame (Fig. 6.11).
6. Additional retraction and isolation (Fig. 6.12). Besides using clamps, the rubber dam can be retained and stabilized using wooden or elastic wedge, stabilizing cords, O-rings, and floss ligature. A caulking agent or liquid dam (for example, Oraseal, Ultradent, South Jordan, UT, USA) can be used if required to improve the sealing of leaking rubber dams.

Fig. 6.9. *Clamp have a four-point contact at the cervical region of tooth*

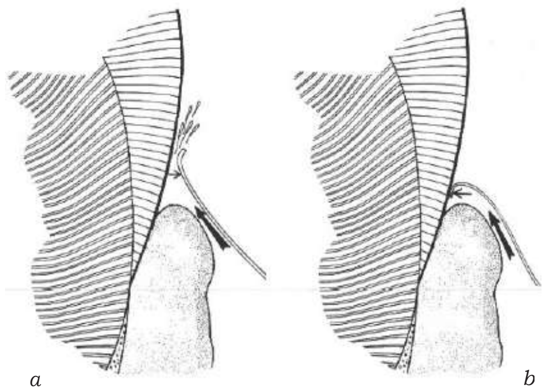


Fig. 6.10. *Importance of inverting the rubber dam into crevice. a – flow of gingival fluid and saliva through the rubber dam perforation; b – by inverting an edge of rubber dam inside gingival crevice, the passage of fluids is blocked*

Fig. 6.11. Rubber dam is stretched with rubber dam sheet

Fig. 6.12. Additional retraction with wooden wedge

7. Removal of rubber dam. After the end of restorative procedure, clamp must be carefully removed from the tooth. Rubber sheet is then stretched, and rubber in the interproximal area is carefully cut.
   Rubber dam can be placed in the patient's mouth using different techniques, depending on tooth, treatment plan, child's behaviour, clinician preference and education.

Methods of rubber dam placement

One-step technique − placement of the whole set: clamp, dam, and frame. In this technique, winged clamps must be used for both anterior and posterior teeth. Disengage the forceps and check the clamp is stable, then use an excavator to release the dental dam from wings (Fig. 6.13).

Placement of rubber dam over a prepositioned clamp – is used for isolation posterior teeth with wingless clamps, or in split-dam technique (Fig. 6.14).

Placement of clamp over rubber dam – is used for isolation anterior teeth.

Placing rubber dam in only one tooth is sufficient when there is no involvement of the approximal area; here during treatment caries on occlusal surface, application of pit and fissure sealant, and endodotic treatment. In cases of class II preparations, a minimum of one tooth mesially and one distally to the tooth being treated should be isolated. Thus, easier and most used approach when use of rubber dam is desired in such clinical situations is use of the "split-dam" technique (sleeve technique) (Fig. 6.15).

For the sleeve technique,several holes are punched "one by one" in rubber dam sheet approximately 5 mm apart; scissors are then used to cut the dam to join these holes together.

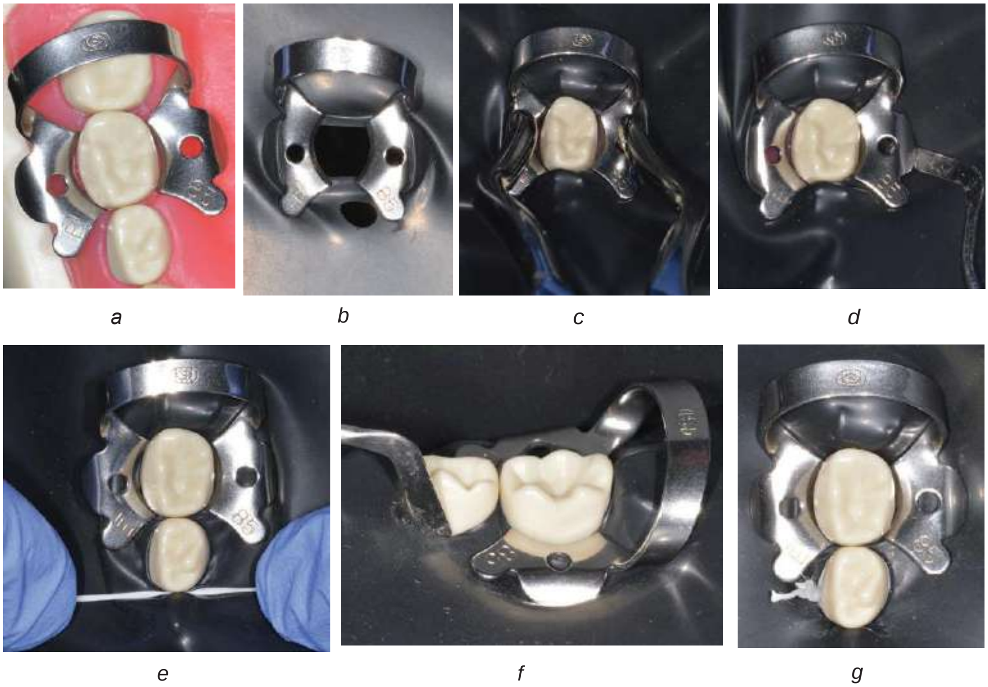


Fig. 6.13. First primary molar isolation with winged clamp 85: testing the clamp (*a*); rubber dam is stretched over the wings of selected clamp (*b*); dam and clamp are placed in position around the posterior tooth (*c*); dam is slipped beneath the clamp wings (*d*); rubber dum is then passed over the most mesial tooth included in perforations (*e*); inverting rubber dam edges (*f*); use dental floss to stabilize rubber dam (*g*)

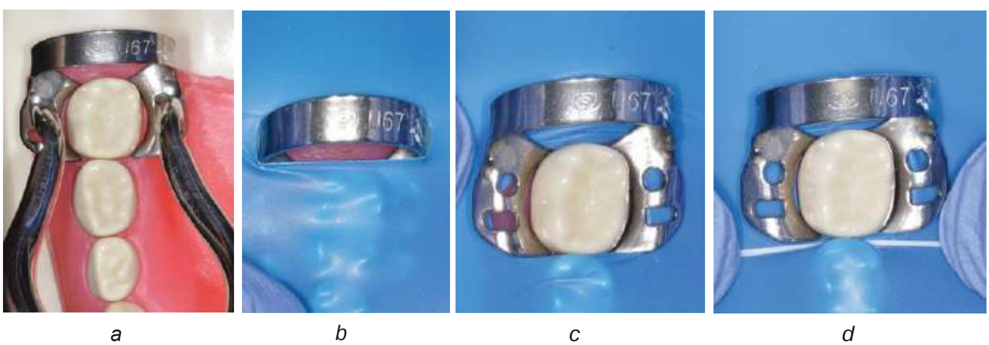


Fig. 6.14. First primary molar isolation with wingless clamp U67: testing clamp and placed in position around the posterior tooth (*a*); stretch dental dam over bow of the clamp (*b*); rubber sheet has been slid below the clamp,which is already in place (*c*); rubber is passed between the remaining teeth with dental floss (*d*)

a *b* *c*

Fig. 6.15. First primary molar isolation in "split-dam" technique: punching the holes in rubber dam sheet (*a*); placement winged plastic Soft Clamp (Kerr) (*b*); placement winged metal clamp (*c*)

FILLING OF CARIOUS CAVITIES IN PRIMARY AND PERMANENT TEETH IN CHILDREN

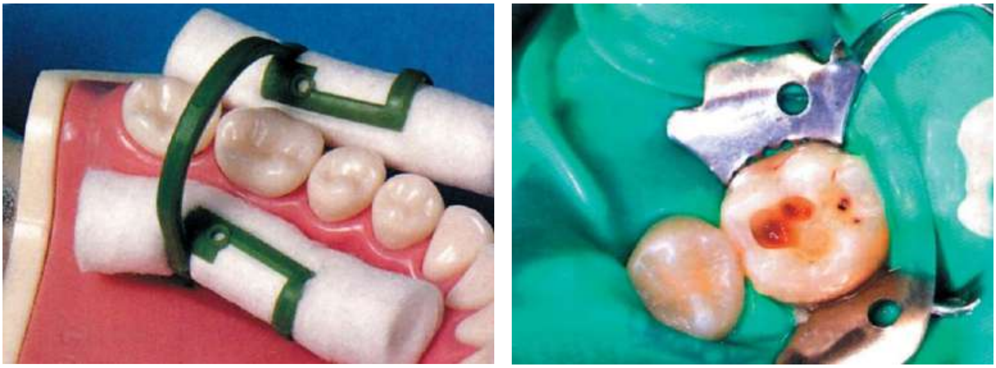
Filling is the final stage of surgical treatment of dental caries and its complications and consists of filling the carious cavity with filling material, as a result of which the anatomical shape and functional value of tooth are restored.

Modern filling materials restore not only the shape and appearance of the tooth, but also its biomechanical and aesthetic characteristics, provide micromechanical and chemical connection of the filling with hard tooth tissues. Filling of carious cavities using modern highly esthetic composite materials is called restoration (aesthetic restoration) of the tooth.

Regardless of what filling material the carious cavity will be filled with, the filling should restore the barrier function of enamel, the contact points of tooth crown and the physiological properties of crown part of the tooth as a whole.

Main stages of filling of carious cavity:
- isolation of tooth from saliva;
- antiseptic treatment of carious cavity;
- drying of carious cavity;
- imposition of insulating (liners) or medicated (if necessary) caps;
- introduction of filling material into the carious cavity and its condensation;
- modeling of filling;
- isolation of the filling from saliva (if necessary);
- finishing of the filling – grinding and polishing.

Isolation of tooth from saliva is the important stage of filling because the sa- liva that got into carious cavity during filling causes a loose fit of filling material to the walls of carious cavity, can lead to development of secondary caries or loss



a b

Fig. 6.16. Isolation of the tooth from saliva: *a* – with cotton rolls; *b* – with kofferdam

of the filling. Isolation of the tooth from saliva is most often carried out with cotton rolls, which cover the tooth from vestibular and oral surfaces, or with the rubberdum (Fig. 6.16).

In case of increased salivation observed in children, the rolls should be replaced by dry ones in time. It is advisable to use a saliva ejector.

Antiseptic treatment of the carious cavity is aimed at the complete removal of pathogenic microorganisms, since even the most thorough preparation of carious cavity does not provide this. 3 % solution of hydrogen peroxide or a 2% solution of chlorhexidine bigluconate are most often used for antiseptic treatment of carious cavities in permanent teeth. In temporary teeth the same antiseptics are used for antiseptic treatment of carious cavities, but in lower concentration. Antiseptics are introduced into carious cavity with sterile cotton balls and left for a while (1–2 min).

Carious cavity should be dried for 10–20 s after antiseptic treatment with an air jet, regardless of what filling material will be used.

Insulating or medicated cap should be applied to avoid a negative impact of filling materials on the pulp.

This stage is especially important when filling primary and permanent teeth in children, since distance from the bottom of carious cavity to the pulp is insignificant, the dentine tubules are wide and development of complications occurs quite quickly in case of violation of the filling rules. With the help of insulating cap it is possible to protect reliably dentin and pulp from an effects of toxic substances (acids, free monomers) contained in some filling materials, to prevent thermal ir- ritation of the pulp when filling with amalgam, to increase the adhesion of filling materials with low adhesive properties.

The insulating cap must meet certain requirements and perform a number of functions:

– provide long-term protection of the dentin and the pulp from chemical and thermal irritation by a permanent filling material;
– seal dentin surface, preventing microbial invasion, irritation and hypersensitivity of the pulp after preparation and filling of carious cavity;
– withstand mechanical stress caused by the redistribution of chewing pressure;
– it should be easily entered into carious cavity, quickly harden and be firmly connected with the dentin;
– facilitate fixation of permanent filling material, not to violate its properties;
– provide anti-carious effect, stimulate remineralization of the underlying dentin;
– not to irritate the pulp of tooth, not to have toxic effect on it;
– not to dissolve under the action of dentine fluid.

Zinc-phosphate and glass-ionomer cements are most often used as insulating caps. The thickness of insulating cap is usually 1–1.5 mm, it should repeat the shape of carious cavity and completely cover its bottom (Fig. 6.17). If the carious cavity is filled with self-curing composite materials, the cap should cover the bot- tom and walls of carious cavity to the level of enamel-dentin junction.

Kind of insulating cap is a liner cap. It differs from the usual one in thickness, that does not exceed 1 mm. A liner cap does not protect the pulp from thermal stimuli, although it performs other functions of an insulating cap. There are special dental materials for this type of caps – liners.

During treatment of acute deep caries in permanent and primary teeth in children, first a medicated cap is applied to the bottom of carious cavity. Medicated caps are used in case of accidental exposure of the pulp during preparation of carious cavity, as well as during the treatment of pulpitis with biological method.

a *b* *c*

Fig. 6.17. *Application of insulating cap made of zinc-phosphate cement (ZPC) to the bottom of class I carious cavity 1: a – introducing the cement mass with carver; b – condensation of the cement mass with plugger; c – final form of the insulating cap of ZPC*

Filling materials including drugs that have therapeutic effect on the pulp of tooth, are used for medicated caps. Requirements for materials used as a medicated caps:

– antimicrobial and anti-inflammatory effect;
– no toxic and irritating effect on the tooth pulp;
– no negative impact on the processes of hardening and adhesion of composites.

Depending on the active components included in the composition, medicated caps are divided into 3 groups:

– the 1st – on the basis of calcium hydroxide;
– the 2d – on the basis of zinc-oxide eugenol;
– the 3rd – combined treatment pastes.

Medicated caps usually have the consistency of paste. Therefore, for the conve- nience of further filling, the medicated cap is covered with an insulating cap from above. As a result, the filling consists of three layers: medicated cap, insulating cap and permanent filling material.

Materials based on calcium hydroxide are most often used today as medicated caps. Calcium hydroxide is the base, slightly soluble in water, has highly alkaline reaction (pH = 12). This reaction gives the main antiseptic and therapeutic effect, facilitates remineralization of carious dentin at the bottom of carious cavity and formation of replacing dentin from the pulp.

There are two groups of medications based on the calcium hydroxide: water suspensions of calcium hydroxide and calcium-salicylate cements of chemical or light curing hardening.

A water suspension is a powder of pure calcium hydroxide mixed in water or saline. The medication of this group is non-hardening paste. It is available in syringes with a needle applicator or in sealed bottles. During clinical application the suspension is applied to the bottom of carious cavity and dried with a stream of warm air, resulting in thin layer of powder of calcium hydroxide on the bottom of carious cavity. It creates and sustains high-alkaline environment there for a certain time, thus providing the therapeutic effect of medication. Over time (in 3-6 weeks), calcium hydroxide layer dissolves under the action of dentin fluid. So medications based on the suspension of calcium hydroxide are applied only under temporary filling for the period of not more than 1,5 months in those cases when strong but short-term impact is needed, for example, to stimulate the closure of the perforating hole with replacing dentin due to accidental exposure of the pulp during preparation.

Calcium hydroxide suspension should be stored in airtight container. It should not be in contact with air, because there can be a chemical reaction of calcium hydroxide with carbon dioxide, resulting in the formation of calcium carbonate, which does not have medicinal properties, and the drug itself gets inactivated over time.

The composition of calcium-salicylate cements (CSC) includes salicylate ether and calcium hydroxide, forming chelate compounds during interaction. Thera- peutical properties of these materials are slightly worse than of the calcium hy- droxide suspensions. However they are more convenient to use, fairly stable, ac- id-resistant, they have better mechanical strength, less soluble in dentin liquid. Therefore, the cap of calcium salicylate cements can be covered on a permanent filling.

Calcium-salicylate cements can be in form of “paste-paste” (two tubes, of dif- ferent color markings). One tube of “paste-paste” CSC contains the base paste, the other – catalytic. The base and catalytic pastes are mixed before use on a paper block in the ratio of 1:1 with a plastic or metal spatula; mixing time is 20–30 s. The prepared mass is introduced into the carious cavity with a small plugger or at the tip of dental probe and spread with thin layer only in the projection area of pulp horn (Fig. 6.18). The mass should be covered with an insulating cap. There are lightcuring CSC, which are produced in one syringe or in one bottle and are ready to use. Their setting time is 20-40 s under action of lightcuring lamp.

The materials based on the zinc-oxide evgenol, along with materials based on calcium hydroxide, are widely used in practice of pediatric therapeutic dentistry both for the treatment of acute deep caries in primary and permanent teeth, for the treatment of complications of dental caries and root canal filling. The Ba- sis of the therapeutic action of the zinc-oxide eugenol materials is antiseptic and anti-inflammatory effects of eugenol, as well as antiseptic and osteotropic proper-

a *b*

Fig. 6.18. *Application of medicated cap of the calcium salicylate cement to the bottom of class I carious cavity: a – the prepared*

mass is introduced into carious cavity at the tip of probe; *b* – the medicated cap is applied point-on to the bottom of carious cavity in the projection

area of pulp horn

ties of zinc oxide. Zinc-oxide eugenol materials can be used in the form of paste or cement.

Zinc-oxide eugenol paste can be prepared immediately before use (ex tempo- re) by mixing eugenol or clove oil (liquid) with zinc oxide powder in the pow- der-to-liquid ratio of 3:1 or 4:1 to form dense mass after mixing. Paste is used to completely fill the prepared carious cavity, carefully lapping it to the walls. The paste hardens in mouth after 2 hours. The period during which such temporary filling should be in the tooth is on average 6–8 weeks. At the end of this period, the temporary filling from zinc-oxide eugenol is removed. Carious cavity is pre- prepared if necessary, removing all carious dentin, and filled with a permanent filling material.

Zinc-oxide eugenol (ZOE) cements are produced on the basis of zinc oxide and eugenol. They harden in the oral cavity within a few minutes due to presence of the special catalysts in their composition, which accelerate chemical reaction of zinc eugenolate formation (Fig. 6.19). These include "Cariosan" ("Spofa Dental", Czech Republic), IRM ("DentSplay", UK), etc.

Combined medicines for medicated caps are usually prepared ex tempore by mixing the ingredients just before use. Ready-made combined medicinal pastes for medicated caps are also available. They may include:

– osteoplastic agents – calcium hydroxide, calcium glycerophosphate, dentin or bone chips, hydroxyapatite (synthetic or biological), collagen, etc.;
– anti-inflammatory agents – steroid (prednisolone, hydrocortisone), non-steroidal agents (salicylates, indomethasone);
– antiseptic and antibacterial agents – chlorhexidine, metronidazole, deca-methoxin, etc.;
– proteolytic enzymes – profezyme, imozymase, stomatozyme etc.;
– other drugs – dimexide, various oil solutions, etc.

a *b* *c*

Fig. 6.19. Application of medicated cap made of the zinc oxide-eugenol cement (ZOEC) to the bottom of class I carious cavity: *a* – introduction of the prepared cement mass into cavity; *b* – condensation of the cement mass with plugger; *c* – final view of ZOE cap

in the carious cavity

Combined therapeutic pastes do not harden in a carious cavity, quickly loss their activity. Therefore they are recommended to be applied for a short period of time (1–7 days) and used only in the treatment of inflammatory processes in pulp, replaced with calcium-salicylate or zinc-oxide eugenol cements.

FILLING OF THE CLASS I CARIOUS CAVITIES IN PRIMARY AND PERMANENT TEETH

Composite filling materials, silver amalgam, glass-ionomer cement are used for filling class I carious cavities permanent teeth in children. Glass-ionomer cement, compomers, composite materials are used for this purpose in primary teeth, less often – silver amalgam. The choice of filling material and technique of filling the classs I carious cavity in children depend on the stage of development of permanent or primary tooth, as well as on the depth of carious cavity.

*G*lass-ionomer cement is used mainly for filling class I carious cavities i*n pri- mary teeth* at the stage of root formation, taking into account the relatively simple filling technique and anti-carious properties of these filling materials. In primary teeth at the stage of root stabilization along with glass ionomer cements, com- pomers, composite filling materials and silver amalgam can be used. Working with these materials is technologically more complex, requires good coopera- tion of a child with a doctor. For filling claas I carious cavity in primary teeth at the stage of root resorption glass-ionomer cements can be used, in some cases – zinc-phosphate and polycarboxylate cements.

Glass-ionomer cement, composite materials and compomers, silver amalgam are used for filling of class I carious cavities in permanent teeth with incomplete root formation in children. The choice of filling material depends on the size of carious cavity. Small carious cavities of class I, which do not fall into zone of oc- clusal contact with the antagonist tooth, can be filled with glass-ionomer cement. Large-sized cavities or cavities that fall into zone of occlusive contact should be filled with composite filling materials or silver amalgam. It should be remem- bered that the thickness of the walls of carious cavity should be at least 2 mm for filling with silver amalgam. Coefficient of thermal expansion of amalgam exceeds the same index of hard tooth tissues and there is a threat of breaking off thin walls of carious cavity. Class I carious cavities, covering a significant area of occlusal surface, should be filled with composite filling materials.

Medicated caps based on calcium hydroxide or zinc-oxide eugenol is often used in carious cavities of class I in permanent teeth with incomplete root formation. It is necessary for prevention of complications from the pulp, since the pulp is voluminous in this period of tooth development, its horns protrude closer to occlusal surface of tooth. Remember, that zinc oxide eugenol should not be used as a subbase for composite materials because it inhibits the polymerisaton of resins. The medicated cap must be covered with an insulating cap.

Technique of filling the class I carious cavity with glass-ionomer cements

Glass-ionomer cements are increasingly used in the practice of pediatric therapeutic dentistry taking into account their positive properties: good adhesion to hard tooth tissue due to chemical bonding with dentine calcium, anti-carious action due to long-term fluoride release, relatively simple technique of working. They are used for filling carious cavities of all classes in primary teeth, as well as classes I, III and V carious cavities in per- manent teeth.

Steps of filling of the class I carious cavity with glass-ionomer cement (Fig. 6.20):

– isolation of the tooth from saliva;
– preparation of the carious cavity (antiseptic treatment, drying);
– application of a medicated cap (if it necessary);
– conditioning of hard tooth tissues, if it is provided by the instruction to glass-ionomer cement. Special dentine conditioner (10–25 % solution of polyacrylic acid) is applied to the bottom and walls of carious cavity and washed off with water after 30 s;
– replacement of cotton rolls and drying of the carious cavity for 10–20 s;
- mixing of glass-ionomer cement on a pad with plastic spatula. The powder and liquid is thoroughly mixed for 20–40 seconds in proportions specified in the instructions to filling material;

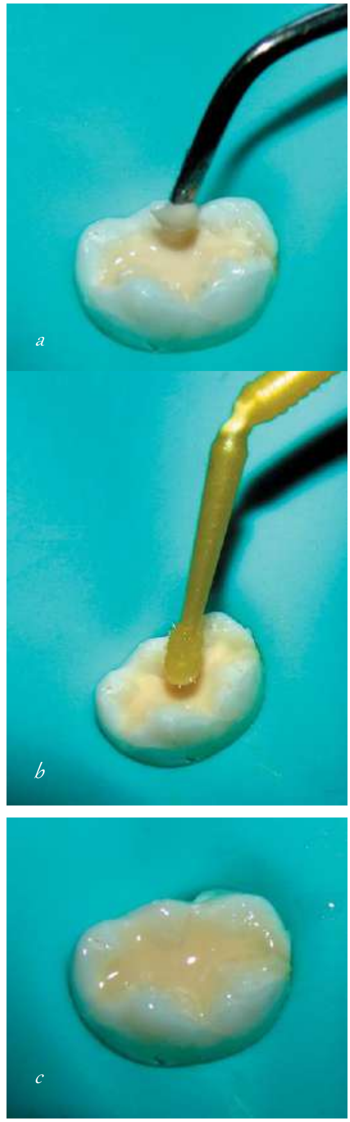


Fig. 6.20. Filling of the class I carious cavity in primary molar with glass-ionomer cement (GIC):
a – placement of the GIS mass into carious cavity;
b – condensation of cement mass; *c* – final appearance of filling after hardening of cement mass

and coating with covering varnish

– placement of the cement mass into carious cavity in one or two portions;
– condensation of cement in carious cavity (a slightly moistened cotton ball may be used);
– modeling of the surface of filling with carver (it is advisable to prelubricate a tool with special gel to prevent the cement mass from sticking);
– after setting of the material (5–7 min from the beginning of mixing) minimal contouring of filling surface with diamond heads;
– isolation of the filling from oral fluid for 24 hours using special covering varnishes ("Ketac Glaze" (3M ESPE), "Final Varnish" (VOCO), etc.), since at this time the glass-ionomer cement is extremely sensitive to excessive moisture;
– finishing and polishing of the filling should be done not earlier than in 24 hours after its application, using diamond heads and polishing discs.

If glass-ionomer cements with the mechanism of light hardening are used for filling, the cement mass after mixing is placed into carious cavity in several por- tions with a certain excess. It is polymerized with curing lamp for 40 s. After hardening the surface of filling is finished and polished, covered with varnish.

Technique of filling the class I carious cavity with composite materials

Composite filling materials are divided into self-curing and light-curing according to the hardening mechanism,. Filling with composite filling materials is more time-consuming procedure compared to filling with glass-ionomer cements, since it requires a number of additional steps.

Steps of filling the class I carious cavity with light-curing composite filling material:

– isolation of the ooth from saliva;
– preparation of carious cavity (antiseptic treatment, drying);
– application of medicated and/or insulating cap (if necessary) of glass-ionomer (zinc-phosphate or polycarboxylate) cement;
– etching of hard tooth tissues with 37 % orthophosphoric acid (gel or liquid) to increase the surface of connection of filling material with hard tooth tissues. Depending on the type of adhesive system, enamel or enamel and dentin etching (total etching) is performed for 15–30 seconds;
– washing of the carious cavity with water jet for the time twice as long as etching time (30–60 s);
– drying of carious cavity with weak stream of air. If dentin was etched, its sur- face should not be overdried, it should remain slightly moistened. To do this,

the air jet is directed into carious cavity not directly, but at angle. Sali- va or blood must not get into carious cavity after etching;

– application of the adhesive system (20 s), uniform distribution by air jet along bottom and walls of carious cavity (5 s) and subsequent polymerization for 10 s. As a result, the zone impregnated with hard- ened adhesive is formed (“hybrid zone”) with which the composite will be connected. Use of the ad- hesive system makes it possible to achieve strong (25–32 MPa) adhesion of composite with dentin;
– placement in portions, condensation and polymerization of the composite filling material. The light curing composite filling material is placed into carious cavity in portions (layers) not more than 2 mm. It is necessary for complete light polymerization of the mate- rial and prevention of significant polymerization shrinkage. While filling cavities it is necessary to place layers not horizontally (in re- lation to bottom of carious cavity), and more vertically and obliquely, closer to the walls of carious cav- ity. Each layer is glued to wall of carious cavity in an appropriate way, modeled, leveled and polym- erized with curing lamp. In this case, polymerization (illumina- tion) is carried out by lamp from the side of carious cavity wall, to which this portion of material

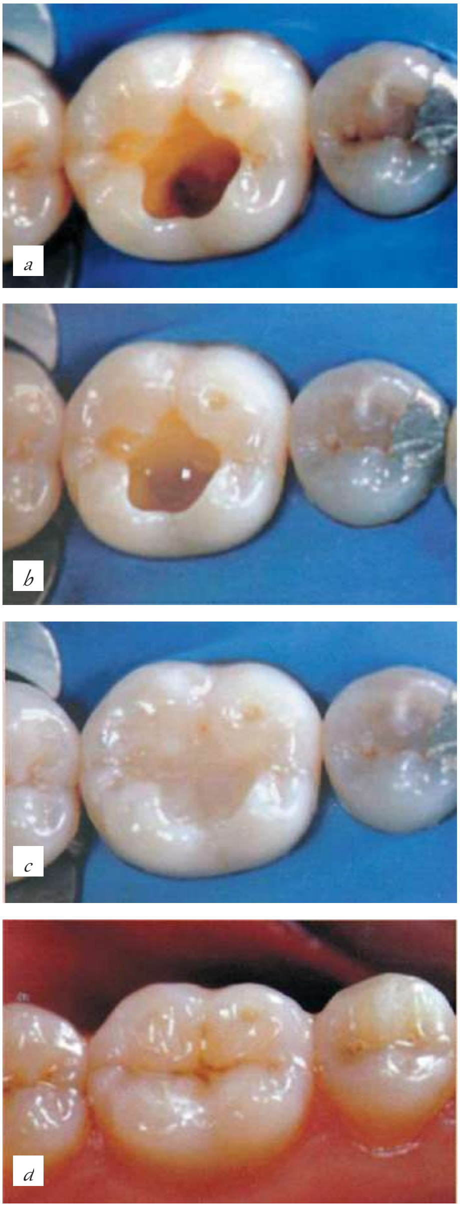


Fig. 6.21. *Steps of filling of the class I carious cavity in the permanent molar with self- curing composite material: a – carious cavity is prepared for filling; b – placement of the adhesive system; c – restoration of cusps and relief of occlusal surface; d – final form of the filling (Putignano A.* and co-authors, 2008)

should be attached (fig. 6.22). This polymerization is called "vectorial". It allows to achieve the best attachment of composite filling material to the walls of carious cavi- ty, as well as to reduce po- lymerization shrinkage. Next portion is applied to the opposite wall and also polymerized until filling material is used to fill the entire carious cavity with a slight excess. Missing dentin is restored with dentin (opaque) shades, and enamel – with enamel shades. The polymerization time of one portion of the composite material for enamel shades and light opaque shades (A1; A2, etc.) is 20 seconds, for dark opaque shades (A3,5; A4, etc.) – 40 seconds. For modeling composite materials it is recommended to use special tools with titanium nitride coat- ing, working part of which has the most adapted shape for different tooth surfaces (Fig. 6.23);

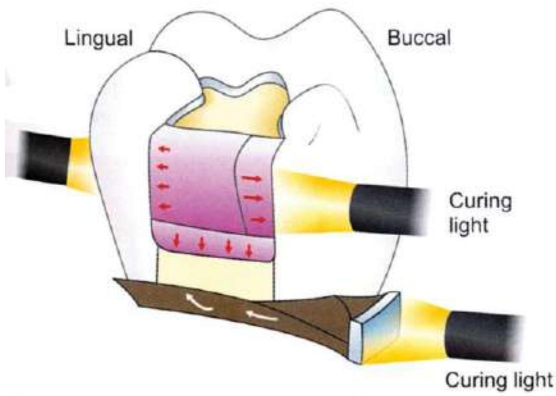


Fig. 6.22. *Direction of polymerized light during polimerization of light-curing composite material for decrease of polymerization shrincage*

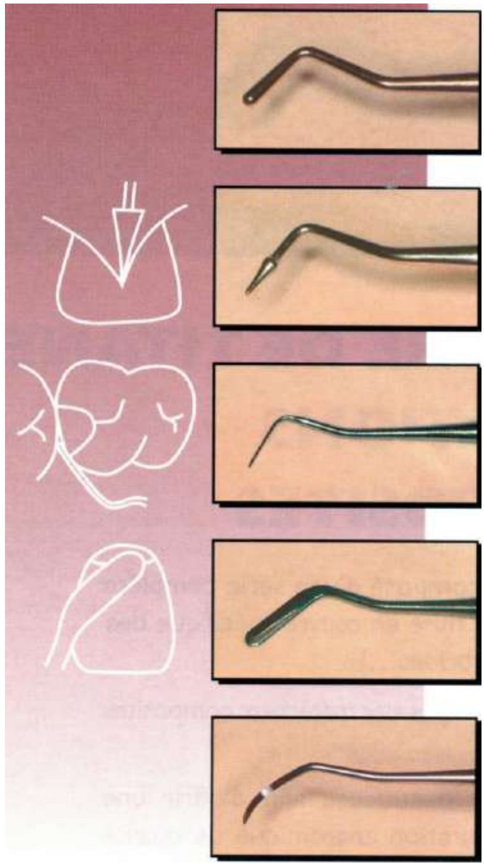
– contouring of the filling surface is carried out with diamond heads. Anatomical shape of the occlusal surface should be reproduced as accurately as possible in order to restore normal occlusal correlation with the antagonist teeth;
– finishing and polishing (to "mirror shine" of dry surface) with special accessories designed for processing of filling made from composites (burs, finishers, polishing discs, polishing pastes of different abrasiveness, etc.).

Steps of filling of the class I carious cavity with self-curing composite filling material (Fig. 6.21):

– isolation of the tooth from saliva;
– preparation of the carious cavity for filling (antiseptic treatment, drying);
– application of a medicated and/or an insulating cap (if necessary) of glass-ionomer (zinc-phosphate or polycarboxylate) cement;
– etching tooth enamel only with gel of the 37 % orthophosphoric acid for 15–30 seconds;
– washing of the carious cavity with water jet for the time twice as long as

etching time (30–60 s);

– drying of the carious cavity with weak jet of air for 10–20
s. Saliva or blood must not get into carious cavity after etching;
– preparation and application of the adhesive system. The adhesive system for self-cur- ing composite filling materi- als is available in form of two bottles with different color marking, which contain a liquid. Mix components in the ratio of 1:1 in special plates with recessions. Enamel is treated with prepared adhesive using special foam sponge. Adhesive lay- er is distributed with weak stream of air (for 5 seconds) on the etched surface;
– preparation of the filling mass of composite material on a pad by mixing the equal parts of base and catalytic pastes with plastic spatula to dough-like consistency of uniform color for 40 seconds. Mixing with metal spatula is not allowed, because the color of filling material may diff ;
– placement of the self-curing composite material into cari-



a

b

c

d

e

Fig. 6.23. *Tools with titanium nitride coating for modeling of restorations of composite materials: a – plugger for applying and compacting of composite material in the carious cavity;*
b – conical tool for modeling fissures and recessions on occlusal

surface;

c – thin carver for modeling of approximal surfaces of restorations;

d – wide carver for modeling of restorations in precervical area; *e* – parodontal curette for removing of excess of adhesive from the dental-gingival furrow

ous cavity in one or two portions with a small excess;

– contouring of the filling surface and removal of underpolymerized surface layer (oxygen-inhibited layer) after full solidification of the material;
– finishing and polishing with special accessories for composite materials.

Technique of filling the class I carious cavity with compomers

Compomers are relatively new class of dental filling materials that combine properties of composites and glass-ionomer cements. One of advantages of these filling materials that attracts attention of pediatric dentists is absence of etching of hard tooth tissues. That"s why the technique of filling with compomer materials is easier and safer, which makes it possible to use them more widely for filling of carious cavities in primary teeth and permanent teeth with unformed root in children. In addition, compomers are available in certain color scheme, which allows to choose the right color and meet the aesthetic requirements for restoration.

Steps of filling the class I carious cavity with compomer:

- isolation of the tooth from saliva;
- preparation of the carious cavity (antiseptic treatment, drying);
- application of a medicated cap (if necessary);
- application of adhesive system to walls and bottom of the carious cavity and its polymerization;
- portioned placement of filling material into carious cavity, its condensation and polymerization. The compomer layer, in contrast the composite, can be thicker (up to 4–5 mm). It makes possible to fill small carious cavities with one portion of material, reducing the time of filling. It is convenient when working with children (Fig. 6.24);
- modeling of the filling and its finishing are the same as when working with composite materials.

a *b* *c*

Fig. 6.24. *Steps of filling the class I carious cavity in the first primary molar with compomer: a – prepared class I carious cavity in the first primary molar; b – medicated cap was applied and adhesive treatment was carried out on the bottom of carious cavity; c – carious cavity is filled with compomer (according to Duggal M. et al., 2006)*

Technique of filling the class I carious cavity with amalgam

Silver amalgam is the most durable and mechanically stable filling material, contributes to long-term preservation of the fillings and tooth function. However the main disadvantage of amalgam is the color mismatch to hard tooth tissues, which significantly limits its use for filling teeth.

Steps of filling the class I carious cavity with silver amalgam:

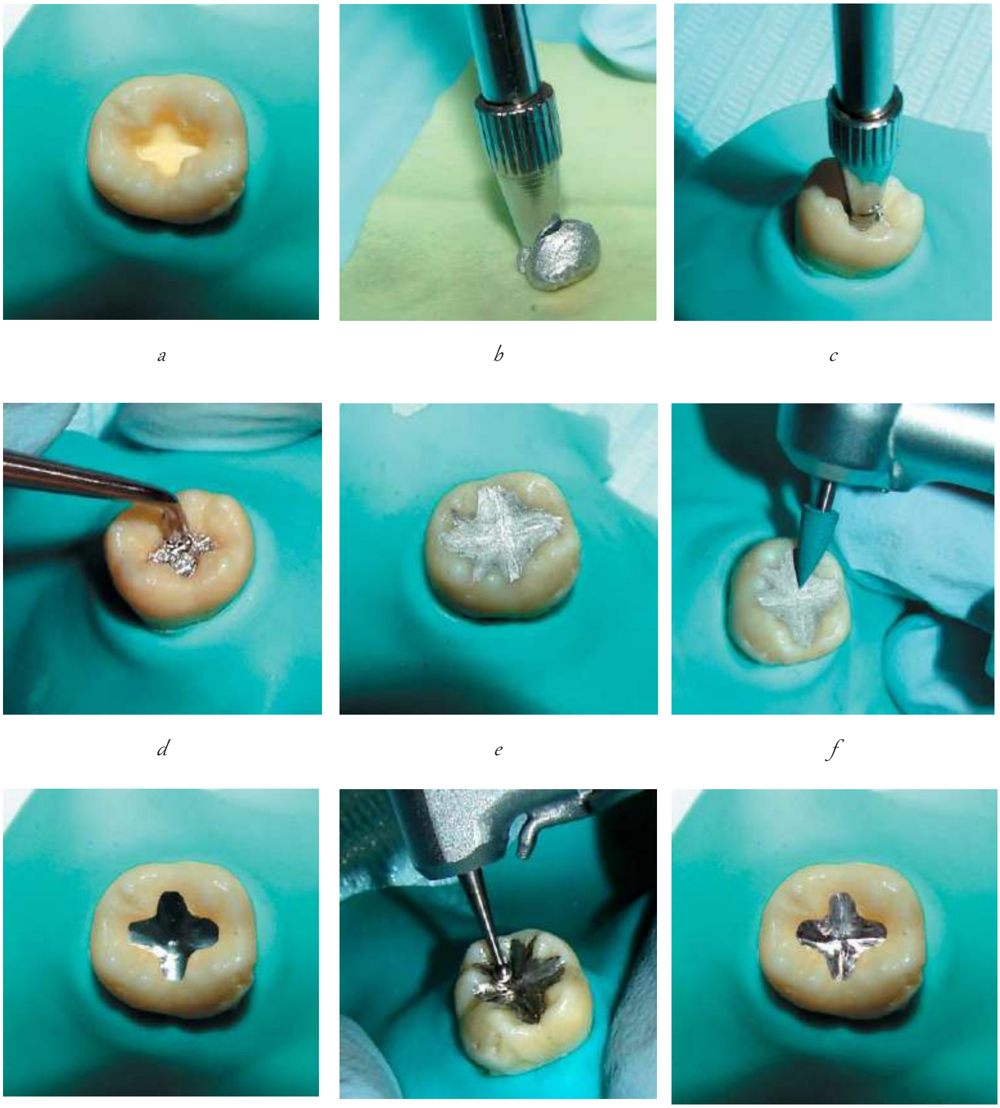
- isolation of the tooth from saliva;
- preparation of the carious cavity (antiseptic treatment, drying);
- application of a medicated and/or an insulating caps. Application of the insulating cap is mandatory step in filling the carious cavity with amalgam. The insulating cap for amalgam filling can be made of zinc-phosphate, polycarboxylate or glass-ionomer cement. Amalgam has high coefficient of thermal conductivity, so in the absence of insulating cap there will be ther- mal irritation of the pulp, which can cause complications after filling;
- preparation of amalgam mass in the special apparatus – amalgam mixers, capsules with silver fillings and mercury are placed in them;
- portioned placement of freshly prepared amalgam mass into carious cavity with special tools – amalgam carriers and syringes for amalgam (Fig. 6.25);
- thorough packing of the amalgam mass in carious cavity (condensation) with special flat plugger with cutting on the working part – amalgam car- rier. The first portion of amalgam is carefully lapped to the bottom and walls of carious cavity with circular motion. Each increment of amalgam is packed with the amalgam carrier, removing excess of mercury from it;
- modeling of the occlusal surface by closing the filled tooth with antagonist tooth and careful removal of excess of filling material;
- finishing and polishing with special accessories for amalgam fillings not earlier than in 24 hours.

Tools for finishing of fillings

Such tools are used for finishing and polishing of fillings:

- rubber and silicone abrasive heads;
- polishing discs;
- polishing brushes;
- abrasive strips.

Rubber and silicone heads are made with different degrees of abrasiveness (Fig. 6.26). Abrasive particles are added to the composition of rubber or silicone, so when finishing and polishing with such heads, there is no need to use a polish-



a *b* *c* *d* *e* *f* *g* *h* *k*

Fig. 6.25. Steps of filling of the class I carious cavity with amalgam *a* – insulating cap is applied to the bottom of carious cavity; *b* – freshly prepared amalgam mass is put into amalgam carrier; *c* – the first portion of amalgam is introduced into carious cavity; *d* – amalgam is carefully lapped to walls of carious cavity and pressed with flat plugger with cutting (amalgam carrier); *e* – the filling after hardening of amalgam; *f* – surface grinding with abrasive silicone heads; *g* – the filling after polishing; *h* – polishing of the surface of filling with metal finishers; *k* – final appearance of the amalgam filling

ing paste. The filling should be processed with mechanical handpiece at low speed with air-water cooling to avoid overheating of the treated surface.

Polishing discs are small abrasive discs with one-sided (rarely two-sided) application of abrasive (Fig. 6.27). Discs are made of paper or plastic base. In the center of disc there is special hole to fix it on the disc holder. Polish- ing discs have 3–4 different degrees of abrasiveness: high (C), medium (M), low (F), very low abrasiveness (FX). Consistent application of discs makes it possible to achieve high quality of polishing of the fill- ing surface.

Polishing brushes are made of polymer bristles, in which abrasive particles are impregnated. Thanks to this design, they do not require polishing paste, do not damage enamel, surface and edges of the restoration. It is especially conve- nient to use brushes for processing concave or convex surfaces of res- torations (fissures, precervical area, etc.) (Fig. 6.28).

Abrasive strips are designed for processing of restorations on the contact surfaces of teeth. Strips – thin, long plastic or metal strips, abrasive is applied on one side of it: diamond grain, aluminum oxide of various dispersity, etc. In the mid- dle part of the strip there is area

a *b*

Fig. 6.26. Polishing silicone heads of different shapes and different degrees of abrasiveness: *a* – for amalgam and cement fillings; *b* – for composite materials fillings

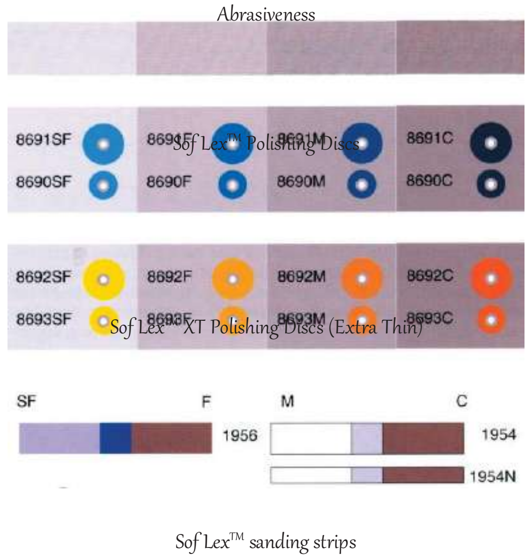


Fig. 6.27. Discs and strips of various abrasiveness for grinding and polishing of composite materials restorations

without abrasive to facilitate insertion of abrasive strip into interdental space.

For finishing and polishing of the fillings fine-grained diamond heads (yellow, white mark), and carbide polyhedral finishers are used (Fig. 6.29).

Fig. 6.28. *Polishing brushes*

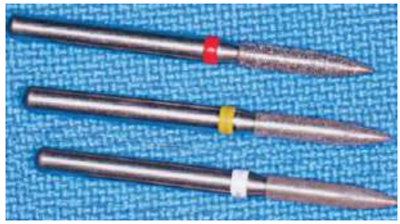


Fig. 6.29. *Fine-grained diamond heads for finishing of restorations*

Filling of the class II carious cavities in primary and permanent teeth

Filling of the class II carious cavity is quite difficult task, since there is no ap- proximal (contact) wall of the carious cavity and contact point of tooth is absent. Therefore, very important task is restoration not only of aproximal wall, but also creation of the high-quality contact point when filling the II class carious cavity. *Contact point* is the most convex part of approximal surface of tooth, in con- tact with nearby tooth. In case of minimum contact surface, the point contact is formed. The form of contact point changes with age as a result of physiological abrasion of hard tooth tissues. The convexity of approximal surfaces decreases, approximal surface becomes flatter and the point of contact becomes planar.

To restore the anatomical shape of tooth and create contact point when filling the class II carious cavity, matrices are used. The matrix serves as a boundary for filling material and prevents its excessive placement and removal beyond the anatomical contour of tooth. Using a matrix, artificial approximal wall of tooth is created, contact point is formed, that is correct anatomical shape of the tooth is restored. Matrix also provides conditions for packing of the filling material, protects dental-gingival papilla from the pressure of filling material.

Matrix is applied before acid etching and bonding. After applying matrix, it should be stabilized by a wedge. Matrix should extend 1 mm beyond the incisal and gingival cavosurface margin.

Classification of matrices

1. According to the shape:
– flat;
– convex (with moderate curvature);
– curved (with considerable curvature);
– curved with a fixing device.
2. According to the type of band material:
– plastic-transparent (celluloid, cellophane, etc.);
– stainless steel;
– combined (metal/plastic).
3. According to the method of imposition and topography of restored areas of tooth crown:
– sectional – cover one contact surface (one sector of the tooth crown);
– circular – cover the entire tooth crown;
– special – restore individual parts of the tooth crown;
– angular matrix – to restore the crown angle of incisor;
– cervical matrix – for filling the precervical carious cavity;
– matrix caps repeat anatomical shape of the tooth crown.

Special devices and tools are used for adaptation of matrix in the interdental spaces, its reliable fixation and prevention of displacements during filling. Today, there are 3 main types of devices for fixing matrices in the oral cavity.

1. Classic matrix holders (for example, the matrix holders Tofflemire, Ivory) – provide a reliable, tight fixation of matrix, but they are quite cumbersome, which makes it difficult to view the working field and filling process (Fig. 6.30).
2. Rings for matrix fixation are made from special elastic stainless steel (Fig. 6.31). Their compact size and elasticity allow the matrix to be held securely without impairing the visibility of a working field. The imposition and re- moval of rings to fix matrices is carried out with special forceps.
3. Devices of tension type connected to the matrix – allow to cover crown part of tooth tightly with the ring matrix (Fig. 6.32). Matrices connected to the tension ring are made of steel or transparent plastic, the ring is made of aluminum. Compression of aluminum ring in horizontal plane provides tension of the matrix and its fixation around tooth.

Interdental wedges are designed for adaptation and tight pressing of the matrix to hard tooth tissues in precervical area, as well as to prevent formation of a ledge (step) of filling material in the process of filling. Modern wedges are an-

a

b

c

d

Fig. 6.30. *Metal matrices for premolars and molars (a, d) and matrix holders of Tofflemire (b); Ivory (c)*

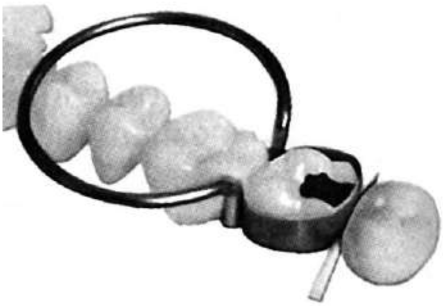


Fig. 6.31. *Ring for matrix fixing*

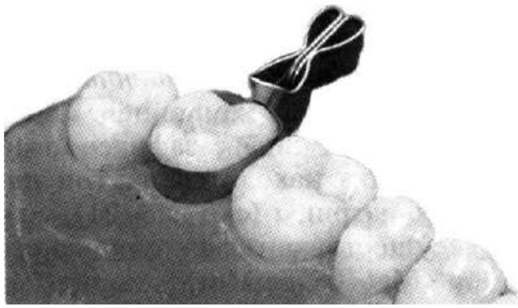


Fig. 6.32. *Matrix is connected to the aluminium tension ring*

atomically shaped and correspond to the contour of interdental space. They are made of wood (maple wood) or transparent plastic (light-conducting) to provide vectorial polymerization of light curing composites. There are wedges of different lengths, thicknesses and color codes (Fig. 6.33). Matrix and wedges should be placed in this way, to ensure correct restoration of the contact point, configu- ration of the contact surface of tooth and prevent removal of filling material in interdental space.

Matrices can be used as the part of matrix system – the set of tools and accessories for clinical application of matrices. The matrix system includes: matrices of various sizes and forms, devices for fixing matrices in the oral cavity, inter- dental wedges and tools for applying and removing of matrices. The sectional matrix system (for example, the system of sectional contour matrices "Palodent" (DentSplay) is convenient for filling class II carious cavities in the lateral teeth (Fig. 6.34).

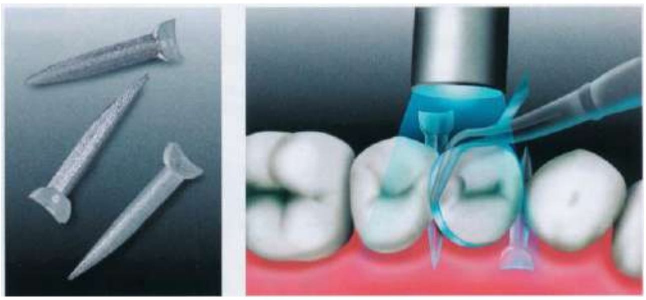
Technique of filling the class II carious cavity with glass-ionomer cements

Glass-ionomer cement is used for filling class II carious cavities in primary teeth only. This material is not used for filling of the class II carious cavities in permanent teeth, because its mechanical strength is insufficient to counteract the chewing load.

Steps of filling the class II carious cavity in primary teeth with glass-ionomer cement:

- isolation of the tooth from saliva;
- placement of a retraction cord into the tooth-gingival furrow;
- selection, application and fixation of the matrix (using wooden wedges) in the interdental space;

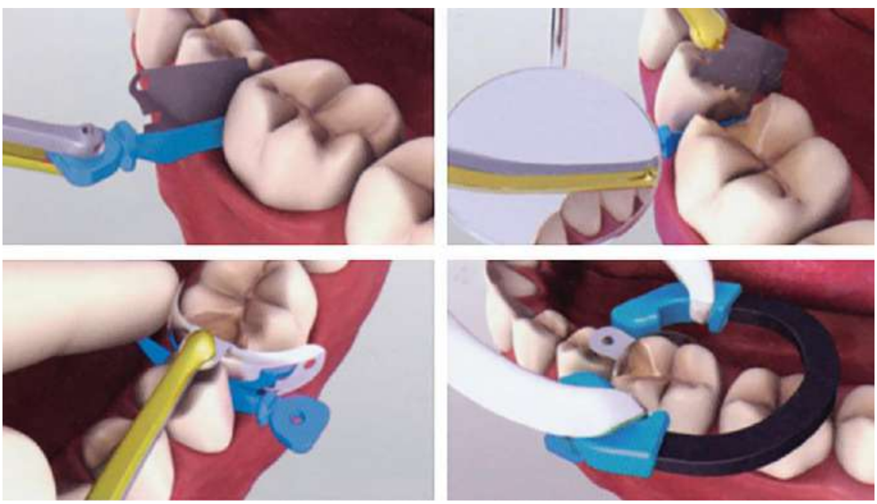
a



b

Fig. 6.33. *Interdental wedges for fixing matrix in the interdental spaces: a – wooden; b – transparent plastic (light-conducting)*

a



b

c *d*

Fig. 6.34 Application of the system of contour matrices "Palodent" (DentSply): *a* – placement of wedge with protection before preparation to protect approximal surface of adjacent tooth; *b* – removal of protective barrier after preparation; *c* – placement of contour matrix with wedge into interdental space; *d* – stabilization of the matrix and teeth separation with Palodent V3 ring at the same time

- application of a medicated cap (if it necessary);
- conditioning of hard tooth tissues according to the instructions provided. Dentin conditioner is applied to bottom and walls of the carious cavity and rinsed with water for 30 s;
- replacement of cotton rolls and drying of the carious cavity;
- mixing of glass-ionomer cement for 30–40 seconds on a pad with plastic spatula with thorough mixing of powder and liquid in proportions according to the instructions provided;
- placement of GIS mass into the carious cavity in one or two portions;
- packing of the cement mass in the carious cavity (a slightly moistened cotton ball can be used);
- modeling the surface of filling with carver (it is advisable to prelubricate the tool with special gel to prevent sticking of cement mass);
- after setting of the material (in 4–5 min), matrix is gently removed from interdental space towards the entrance of oral cavity;
- removal of a retraction cords;
- minimal contouring of the filling surface with diamond heads;
- isolation of the filling from saliva for 24 hours with special covering var- nishes ("Ketac Glaze" (3M ESPE), "Final Varnish" (VOCO), etc.);
- finishing and polishing of the filling after 24 hours. Diamond heads and polishing discs are used.

Technique of filling the class II carious cavity with composite filling materials

Composite filling materials widely used for filling of the class II carious cav- ities in permanent teeth as they have good mechanical and aesthetic properties. Hybrid composites of opaque colors or nanocomposites with high filler content meet the requirements for restorations in lateral teeth.

When filling the class II carious cavity, different filling techniques can be used: adhesive technique, bonding technique, sandwich technique and technique of filling, providing combination of different types of composite materials in one restoration.

A**dhesive technique** consists of the restoration of tooth with one, as a rule, microgibrid composite material (or nanocomposite) with application of the adhesive system provides bonding both with enamel and dentin. Application of insulating (medicated) cap is not necessary in this case, except for deep carious cavities.

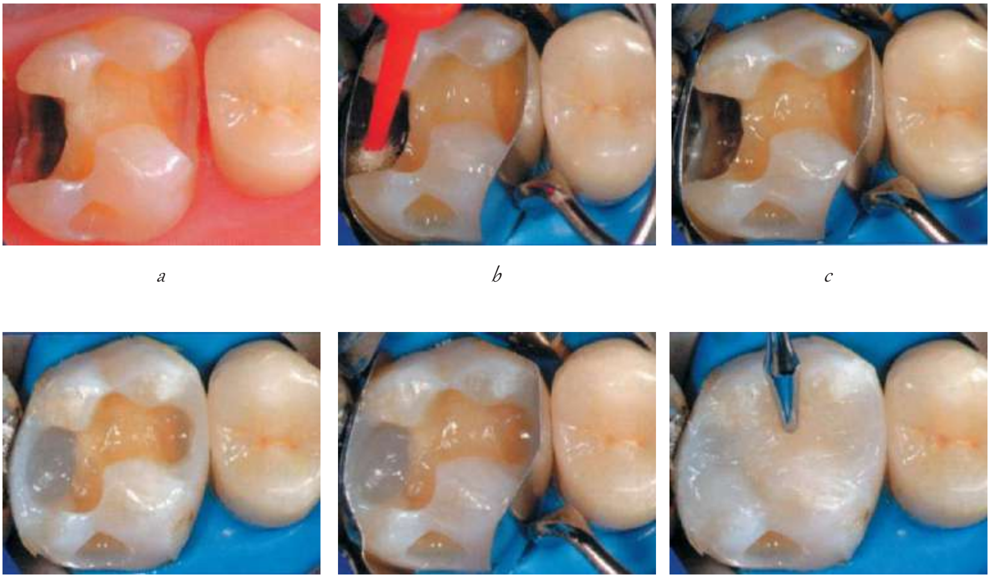
Bonding technique is used for filling of composite materials with adhesive system that provides connection with enamel only. In this case, the insulating liner (thin cap) made of zinc-phosphate, polycarboxylate or glass-ionomer cement is applied on the dentin at bottom and walls of carious cavity clearly up to the enamel-dentin connection.

Sandwich technique involves the imposition of filling, containing two layers: internal – glass-ionomer cement and external – composite material. There are two variants of sandwich technique: "closed sandwich" and "opened sandwich". In the case of "closed sandwich" a layer of glass-ionomer cement is completely covered with composite, and it does not come into contact with oral cavity after filling. In the case of "open sandwich" a cap of glass-ionomer cement overlaps the pregingival wall of carious cavity, partially restores the approximal surface of tooth in precervical region and contacts with oral cavity after filling.

Technique of filling with use of different types of composite materials in one restoration provides for the combination of traditional, flow and packed com- posites when applying the filling. These materials are combined in one restoration in order to maximize use of positive properties and minimize negative ones. Ad- hesive systems of 5th and 6th generations should be used during this technique of filling.

Steps of filling the class II carious cavity with light curing composite (Fig. 6.35 , 6.36) (adhesive filling technique):

- isolation of the tooth from saliva;
- placement of a retraction cord into the tooth-gingival furrow;
- selection, application and fixation of the matrix. When filling carious cavity with composite, it is advisable to use transparent (clear polyester strip) matrices and light-conducting wedges to conduct vectorial polymerization of composite. Using the same wedges, be sure to carry out wedging of teeth in order to form the qualitative contact point;
- preparation of the carious cavity for filling (antiseptic treatment, drying);
- application of a medicated and/insulating cap (if necessary) of glass-ionomer (zinc-phosphate or polycarboxylate) cement;
- etching of hard tooth tissues (enamel and dentin) with 37 % orthophosphoric acid (gel or solution) for 15–30 seconds;
- washing of the carious cavity with water jet for 30–60 seconds;
- drying of the carious cavity with weak stream of air. Saliva or blood should not enter the carious cavity after acid etching;
- application of adhesive system (20 s), its uniform distribution on bottom and walls of the carious cavity using weak air jet (5 s) and polymerization (10 s);
- portions placement and polymerization of composite filling material. The pregingival wall of the class II carious cavity can be restored by self-curing



a *b* *c* *d* *e* *f*

Fig. 6.35. Filling of the class II carious cavity in the permanent molar with light curing composite: *a* – carious cavity after preparation; *b, c* – application of adhesive after matrix placement and etching; *d* – filling of the pregingival part of carious cavity, formation of contact point and marginal ridge; *e* – carious cavity of the class II transformed into the class I cavity; *f* – contouring of occlusive surface of the filling

composite, taking into account that its polymerization occurs in the direction to heat source, it means in the direction to gingiva. This prevents formation of gap between filling material and pregingival wall of the carious cavity by reducing of polymerization shrinkage of the composite. Then the filling with light curing composite material is continued. The first portion of light curing composite material should be packed in the direction to pulp chamber and buccal wall. Composite should reach the buccal edge of carious cavity. Material is polymerized from the buccal surface for 20–40 s. Thus, polymerization shrinkage is directed towards the buccal surface. After that, material is polymerized from the occlusal surface for 20–40 s. The second portion of composite should be placed in the direction to lingual surface up to the lingual edge of carious cavity. It should be polimerized from the lingual surface for 20–40 s. Shrinkage, which is directed to buccal or lingual surface, reduces the stress on cusps during polymerization from occlusal surface;

– modeling of the aproximal surface of filling and the marginal ridge transforms the class II carious cavity in the class I carious cavity;

- modeling of the occlusal surface of restoration;
- removal matrix and additional light curing of filling in the interdental space from vestibular and oral surfaces for 20 seconds for each side;

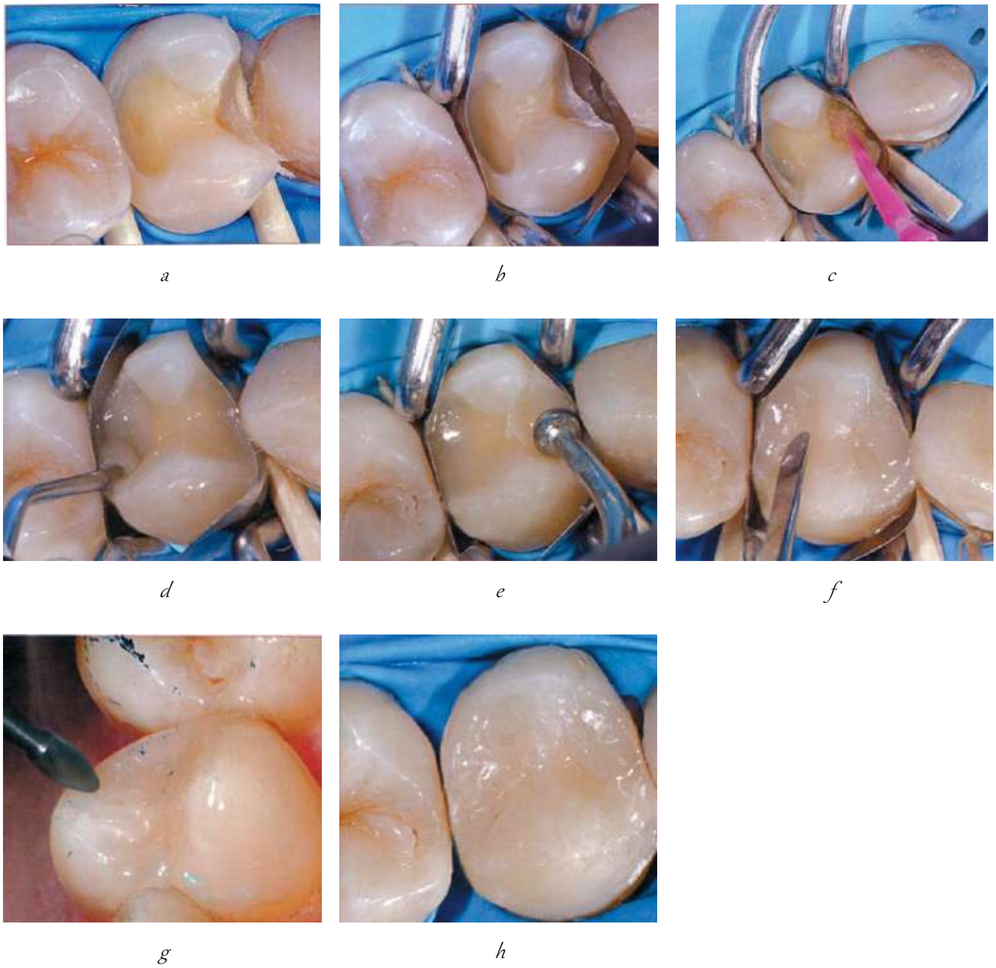


Fig. 6.36. *Steps of filling the class II carious cavity in the permanent premolar with light curing composite: a – carious cavities after preparation; b – applied and fixed matrices; c – application of adhesive system; d – placement of chemical composite to pregingival area of carious cavity; e – placement of nanohybrid composite and forming of contact surface and contact point; f – modelling cusps on the occlusal surface; g – appearance of the filling after finishing and polishing; h – the final look of the restoration*

– contouring the surface of filling with diamond heads. Finishing of approximal surfaces with abrasive finishing strips is carried out after matrix removal, but before removal of wedges. To check the quality of contact point, the matrix should be reinserted into interdental space, and wedges should be removed. Matrix should be fixed in the interdental space and removed from it with a certain effort. Check of the contact point is carried out with dental floss: floss should slide freely on the approximal surface, lingering a little in the area of contact point;

– polishing the surface to “mirror shine” with special accessories designed for the processing of fillings from composites.

Steps of filling the class II carious cavity with self-curing composite:

- isolation of the tooth from saliva;
- carious cavity preparation for filling (antiseptic treatment, drying);
- introduction a retraction cord into the tooth-gingival furrow;
- selection, application and fixation of matrix in the interdental space;
- medicated and / or insulating cap of glass-ionomer (zinc-phosphate or polycarboxylate) cement must be applied up to the enamel-dentine connection;
- etching the tooth enamel only with gel or solution 37 % orthophosphoric acid for 15–30 seconds;
- rinsing of carious cavity with water jet should be twice as longer as the time of etching (30–60 s);
- drying the carious cavity with weak stream of air. Properly etched surface has frosted appearance. Saliva or blood should not enter the carious cavity after acid etching;
- preparation and application of the adhesive system to enamel, easy drying with weak air jet (5 s) for uniform distribution of adhesive on the etched enamel surface;
- preparation of composite filling mass by mixing of equal parts of base and catalytic paste for 30–40 s with plastic spatula on a pad to the dough-like consistency of uniform color;
- placement of the self-curing composite material into carious cavity in one or two portions with a small excess (Fig. 6.37);
- removal of matrix and retraction cord after final hardening of material;
- contouring of the filling surface and removal under-polymerized surface layer;
- finishing and polishing of the filling with special accessories for composite materials.

The sandwich-technique of filling the class II carious cavities is used mainly in permanent teeth in children both at the stage of unformed root and at the stage of fully formed root. It is indicated for patients with problematic oral cavity, namely with severe caries (a large number of carious teeth, low level of oral hygiene, high frequency of recurrent caries).

The sandwich technique has a number of advantages compared to adhesive technology: the glass-ionomer cap plays role of a shock absorber under the composite, compensaties the polymerization stress of composite and pressure on the filling in chewing process. Glass-ionomer cement prevents development of secondary caries and ensures sealing capability of the filling for a long time. However, the sandwich technique is more time-consuming and involves filling of the carious cavity in two visits. During the first visit carious cavity is filled with

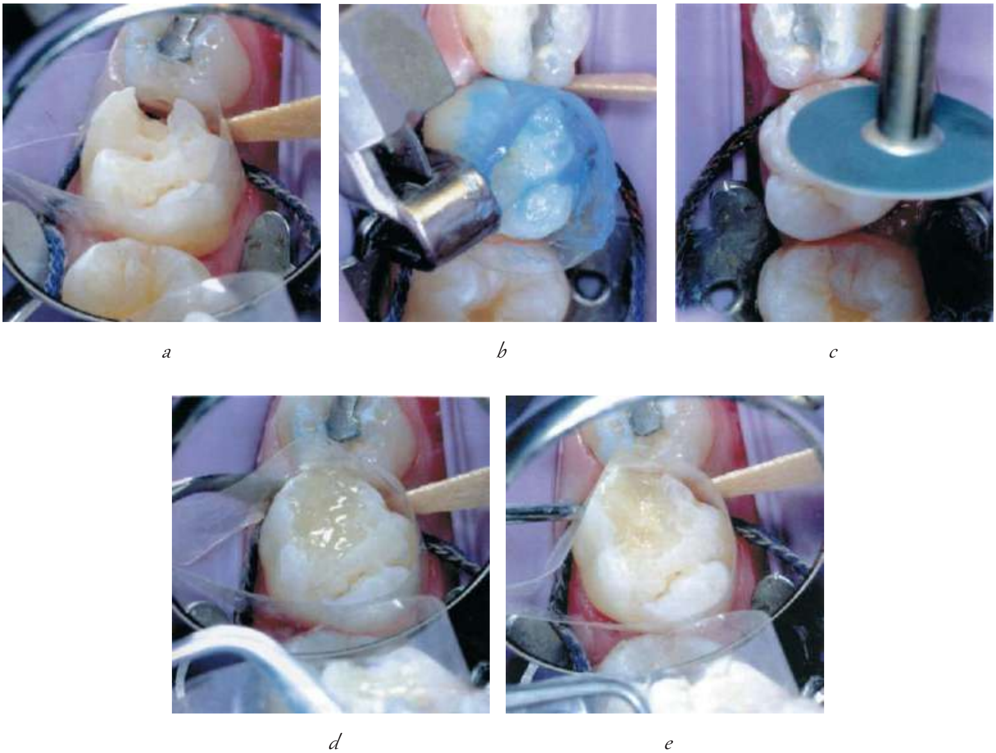


Fig. 6.37. Filling of class II carious cavity in the primary second molar with self-curing composite filling material: *a* – fixation of transparent matrix with wooden wedge; *b* – enamel etching; *c* – introduction of composite filling material into carious cavity; *d* – appearance of filling after polymerization of composite; *e* – finishing processing of the filling (Duggal M. et al., 2006)

glass-ionomer cement after preparation. During the second visit glass-ionomer filling is partially removed, the enamel edge is processed and carious cavity is filled with composite. Make sure that the contact point has been restored with composite material only.

The filling technique with use of different types of composites in one res- toration (combined restoration technique) (Fig. 6.38) provides for use of 5th or 6th generation of adhesive systems; traditional, flowable and packable com- posites in one restoration. This combination of composite materials is called the "restoration system". After preparation of the carious cavity and application of adhesive system, the "initial adaptive restoration layer" is created. All walls of the carious cavity are covered with a flowable composite, paying special attention to the pregingival wall, angles and irregularities of relief inside carious cavity. The optimal thickness of initial adaptive layer is 0.3–0.5 mm. Due to high fluidity, the flowable composite fills all micro-irregularities, ensuring a tight marginal fit of the filling. In addition, it forms an elastic lining under the filling, which compen- sates polymerization stress of composite.

Subsequent layers of the filling are formed from packable composite or nanocomposite. It is placed into carious cavity in layers 2–2.5 mm thick. Each layer is polymerized separately. Due to low polymerization shrinkage of this type of composites, it is not necessary to apply vectorial polymerization. Packable composite provides strength and spatial stability of the filling. It is advisable to form the contact point of this composite.

The occlusal surface is modeled with thickness of 1–1.5 mm with universal microhybrid or nanofilled composite. This layer gives the filling an aesthetic appearance. The surface of filling is modeled in accordance with relief of occlusal surface. After removal of matrix, an additional 20 s light cure of the filling is carried out from vestibular and lingual sides. The last step of filling is final contouring, finishing and polishing of composite material.

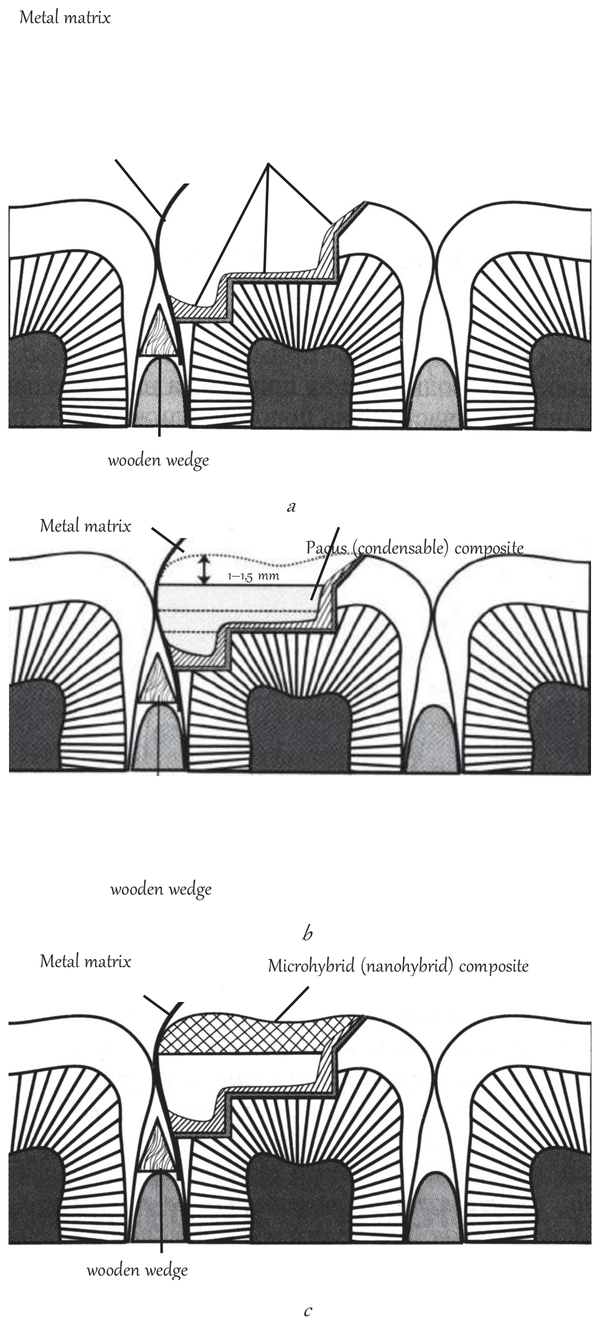


Fig. 6.38. Restoration system of various types of composites for filling of the class II carious cavity: a – creation of initial adaptive layer with flowble composite; b – formation main base of filling and the contact point with packable composite; c – formation the occlusal surface

with nanocomposite

Technique of filling the class II carious cavity with compomer

Due to aesthetic properties and sufficient mechanical strength compomers can be used for filling of the class II carious cavities in both primary and permanent teeth in children.

Steps of filling the class II carious cavity with compomer filling material:

- isolation of the tooth from saliva;
- introduction a retraction cord into the tooth-gingival furrow;
- selection, application and fixation of matrix in the interdental space. Taking into account that compomers are light-curing filling materials, it is advisable to use transparent matrices and light transmitting wedges;
- preparation of carious cavity for filling (antiseptic treatment, drying);
- application of a medicated/insulating cap (if necessary) of glass-ionomer (zinc-phosphate or polycarboxylate) cement;
- application the adhesive system to walls and bottom of the carious cavity (20 s) and its polymerization (10 s);
- placement a portion of the filling material in carious cavity, its condensation and polymerization. The compomer layer can be up to 4–5 mm thick;
- matrix removal and additional polymerization of filling in the interdental space (10 s for each sides);
- retraction cord removal from the dental-gingival furrow;
- final contouring of filling , its finishing and polishing are carried out in the same way as for composites.

Technique of filling the class II carious cavity with amalgam

Silver amalgam, considering its unsurpassed strength characteristics, is ideal material for filling the class II carious cavities in both permanent and primary teeth in children. It should be noted that the contact point formed of amalgam, is maintened for a long time and reliably protects the interdental space. Silver amalgam can be used as the permanent filling material in permanent teeth both at the stage of root formation and at the stage of fully formed root. Silver amalgam is used in primary teeth at the stage of root stabilization only.

Steps of the class II carious cavity filling with amalgam:

- isolation of the tooth from saliva;
- application of a retraction cord into the tooth-gingival furrow;
- selection, application and fixation of matrix. When filling with amalgam, it is advisable to use metal matrices. Matrix fixation in the interdental spaces

should be dense, wooden wedges are used for it. Matrix fixation should be reliable, so that during amalgam packing, carried out with some force. That"s why displacement of matrix and entry of filling material into the interdental space may occur;

- preparation of the carious cavity for filling (antiseptic treatment, drying);
- application of a medicated cap (if it necessary); application of an insulating cap (zinc-phosphate or polycarboxylate) is mandatory;
- preparation of the amalgam mass in amalgam mixer;
- portions placement of freshly prepared amalgam into the carious cavity with amalgam carrier or amalgam syringe;
- packing of the amalgam in carious cavity with amalgam carrier. The first portion of amalgam is carefully lapped to bottom and walls of the carious cavity with circular movements. The next portion is condensed with amalgam carrier;
- matrix removal by carefully removing it from interdental space towards the vestibule of oral cavity;
- removal a retraction cord from the dental-gingival furrow;
- modeling the occlusal surface by carefully closing the filled tooth with tooth-antagonist and carefully removing excess of filling material;
- final processing of the filling (finishing and polishing) is carried out with special accessories for the amalgam fillings not earlier than after 24 hours.

RESTORATION OF PRIMARY TEETH WITH STANDARD METAL CROWNS

Standard metal crowns made of nickel-chromium alloy were firstly used in pediatric dentistry by Humphrey in 1950. They are the best way for restoration of severely damaged primary teeth. Metal crowns are made of various sizes in the form of metal sleeve with modeled elements of the basic tooth anatomy. If necessary, they are cut and contoured to fit to a particular tooth.

There are two types of metal crowns:

1) pre-cut metal crowns (Unitek, 3M Co, St Paul, MN, Denovo, Arcadia, CA). They have straight non-contoured walls, but are cut so that their edge follows the contour of gums. Such crowns usually need contouring and additional cutting;
2) pre-contoured crowns (Ni-Chro Ion, Unitek, 3M Co, St Paul, MN). They have scalloped edge, are also pre-conturated, so they need minimal correction before use.

Indications for use of the standard metal crowns:

- restoration of primary or permanent teeth with unformed root with significant carious lesions. These are primary teeth with caries lesions of three or more surfaces, as well as the first primary molars with medial carious cavity, since the anatomical shape of tooth does not create sufficient conditions for fixation of the class II restorations;
- restoration of primary and permanent teeth with enamel hypoplasia or other congenital malformations of hard tooth tissues, for example, with imperfect amelo- or dentinogenesis;
- restoration of primary teeth after pulp amputation or pulp extirpation;
- restoration of teeth in children with disabilities or in children with poor oral hygiene;
- as a support for orthodontic or orthopedic structures;
- temporary recovery in case of the fracture of tooth crown part.

Steps of tooth preparation and application of standard metal crowns

1. Reducing the height of bite (Fig. 6.39, *a*). This stage is performed with large diamond heads. First, furrows are cut in the fissures, and then the occlusal surface is ground by 1.5 mm. The height of tooth crown decreases, tooth completely leaves the bite and necessary gap for the crown is formed on occlusal surface.
2. Preparation of medial and distal approximal surfaces (Fig. 6.39, *b*). Preparation of approximal surfaces is carried out with the cone fissure bur. It is necessary to grind the contact points with adjacent teeth and make approximal walls of tooth vertical, with some convergence to the occlusal surface. This is necessary in order to create a sufficient gap for the metal crown. You should be careful not to damage the adjacent tooth during preparation process. When preparing the pregingival wall, make sure that a ledge or protruding edge do not form, which will be an obstacle to the fitting of the crown.
3. Rounding of sharp angles and final check of the shape of prepared tooth (Fig. 6.39, *c*). To round angles use lateral surface of the bur. The angles of occlusal-buccal and occlusal-lingual slopes should be rounded off at 30-45 to the occlusal plane. It is necessary to make sure that the necessary volume of hard tooth tissues is removed from occlusal and approximal surfaces without formation of ledges.
4. Choice of metal crown of the required size (Fig. 6.39, *d*) by successive fitting of crowns of different sizes. Purpose of this stage is to find the crown of appropriate size, which sits on the tooth and restores approximal contacts. To put the selected crown on prepared tooth, it is first installed on lingual

side, then pressed from vestibular side so that it clicks. If the crown does not click, it means that it is too big and you should pick up smaller crown. After the crown is installed, its occlusal ratios are checked. The crown may rise above the level of adjacent teeth due to insufficient preparation of occlusal surface, the great length of crown, the presence of an approximal pregingival ledge or insufficiently prepared contact with adjacent tooth. If the gum pales around edge of the crown, this indicates an excessive length of the crown or that its edge is too curved.

5. Crown length correction (if necessary) (Fig. 6.39, *e, f*). Modern crowns are almost never in need of correction. However, if necessary, length of the crown can be corrected. Properly cut crown enters the tooth-gingival fur- row to the depth of 1 mm. Before cutting, crown should be placed on the tooth with sharp tool, for example, hand scaler, mark the level of gingival edge on it. Then crown should be removed and cut 1mm below the mark with scissors or disk with low speeds using straight handpiece. After cutting, edge of the crown should follow contours of the gum in form of successive bends, without straight lines and sharp corners. In the process of adapting of standard metal crown, it is advisable to use special tools (Fig. 6.40).
6. Bending of edges of the crown (contouring, Fig. 6.39, *g*) so that it tightly covers the tooth in precervical area. To do this, the crown edge is pushed inward by about 1mm along its perimeter with crampon forceps. Tight marginal fit provides mechanical fixation of the crown, isolation of fixing cement from saliva, prevents injury of gums. After final contouring of the crown, it should be put on the tooth with difficulty. After crown is installed with probe, it is necessary to check the tightness of its marginal fit around perimeter, as well as quality of approximal contacts. To remove crown, you can use scaler or carver to pry its edge. At the same time, crown should be held with a finger, controlling its movement.
7. Fixing of the crown with cement (Fig. 6.39, *k, l*). Before cementing, edges of the crown are ground and polished. Grinding is first carried out with an abrasive stone, creating a smooth thinned smooth edge. Stone should rotate at angle of 45° to the crown edge. A rubber disc is used to remove metal burrs with light, sweeping movements. After that, the metal crown is washed and dried outside and inside and a cement is prepared. Zinc-phos- phate, polycarboxylate or glass-ionomer cement can be used for fixation. The crown is filled with cement for two-thirds so that all its inner walls are covered. The tooth is dried with an air jet and the crown is finally installed. Before the cement hardens, a patient should

close his teeth in the central occlusion. You should make sure that the crown does not open bite.

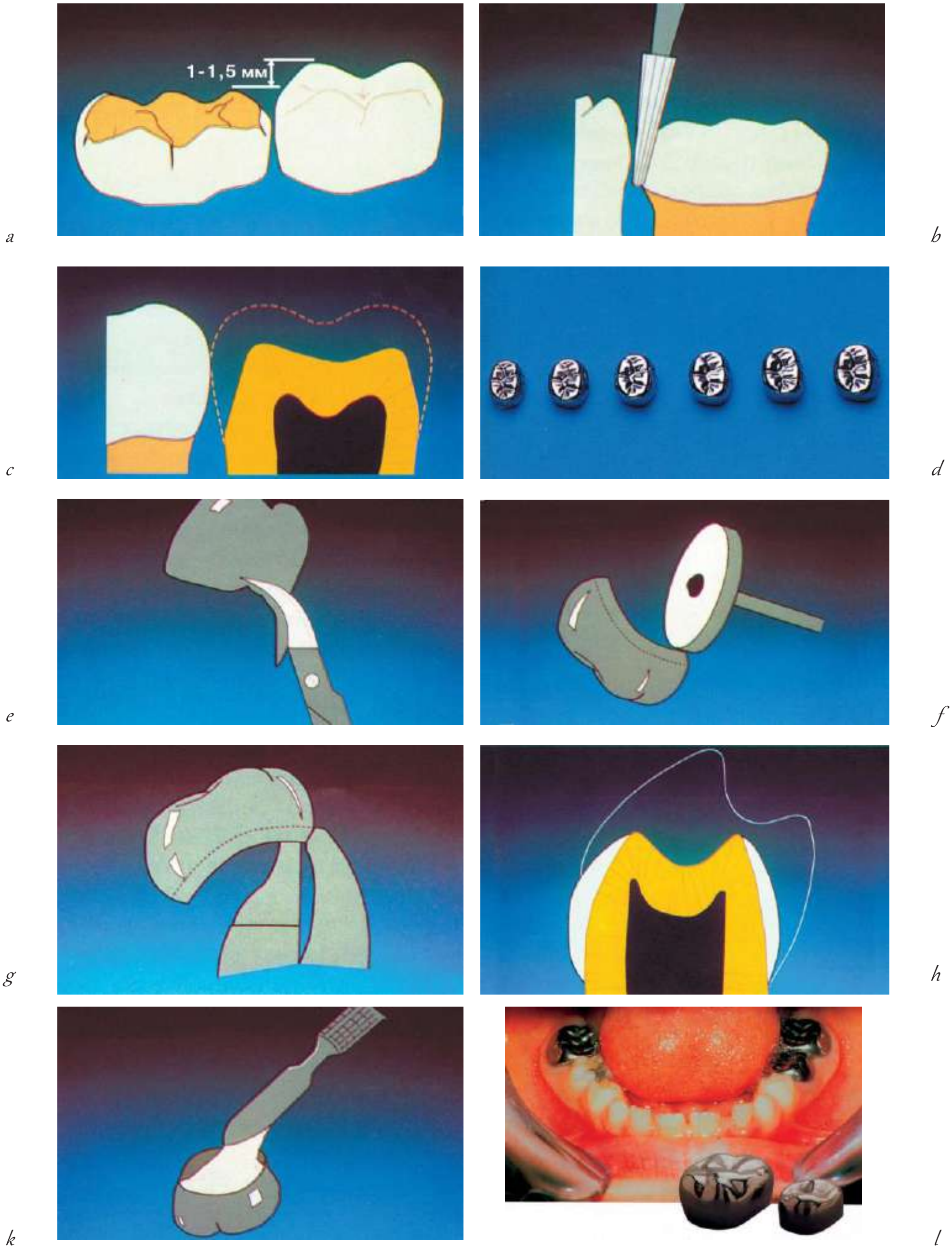


Fig. 6.39. *Steps of restoration of primary molar with standard metal crowns: a – preparation of the occlusal surface to reduce the height of crown of primary molar by 1-1.5 mm; b – preparation of the approximal surfaces of primary molar; c – rounding of the edges; d – selection of the crown of required size; e – correction of the crown height; f – smoothing of the crown edges; g – bending of the crown edges with crampon forceps; h - schematic image of the crown edges after bending; k – filling crown with polycarboxylic cement; l – crowns are fixed on the primary molars*

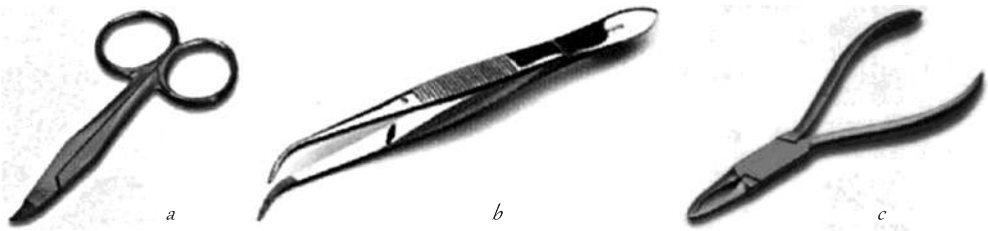


Fig. 6.40. Tools used for adaptation of the standard metal crowns: *a* – scissors for cutting of the crown edges; *b* – forceps to hold the crown; *c* – forceps for bending of the crown edges.

8. Removal of a cement excess and final quality control of the crown. It is nec- essary to wait for a cement to harden to such a consistency that its excess can be easily removed with appropriate tools. Zinc-phosphate cement can be removed with probe or scaler. Polycarboxylate cement after partial hard- ening has a rubber-like consistency. At this stage, excess of cement should be removed with probe. Approximal zones can be cleaned from excess of cement with dental floss, tying a knot on it. At the final stage, crown should be checked again for bite and lightly polished with special paste.

FILLING OF THE CLASS III CARIOUS CAVITIES IN PRIMARY AND PERMANENT TEETH

Modern filling materials - light curing and self curing composites, compomers – are used for filling the class III carious cavities in permanent teeth in children. They can satisfy high aesthetic requirements for fillings in the frontal part of den- tal row. Glass-ionomer cements can be used for filling in case of the small class III carious cavity and preservation of its vestibular (enamel) wall. Glass- ionomer cements, compomers and composite materials are used for filling the class III carious cavities in primary teeth.

Technique of filling the class III carious cavity with composite filling materials

Steps of filling the class III carious cavity with light-curing composite mate- rial (adhesive technique):

1. Cleaning of the tooth surfaces with manual and mechanical tools designed to remove dental deposits, as well as polishing heads, end round ad conical brushes with abrasive pastes that do not contain fluoride;
2. Planning of restoration and choice the shade of restorative material. The anatomical features of tooth, topography of contact points are evaluated

when planning restoration. The main shade of tooth and shades of other parts of the crown (neck, contact surfaces) are determined. Determining the color of tooth and selection of the shade of filling material is carried out with special scales consisting of templates of colors of different shades. "Vita Shade" is considered to be the universal scale. In accordance with this scale, there are four variants of teeth shades, denoted by different letters:

– A – reddish-brown shades; which are designated as A1, A2, A3, A3, 5, A4 depending on color saturation;
– B – reddish-yellow; which are designated as B1, B2, B3, B4 depending on color saturation;
– C – grayish; which are designated as C1, C2, C3, C4 depending on color saturation;
– D – reddish-gray – designated as D2, D3, D4.

Determination of the tooth color should be done before preparation of hard tooth tissues in daylight or artificial (day light lamps) lighting. Do not select the color of tooth when lighting with lamp of dental unit, as this contributes to the erroneous selection of lighter shade. When determining the color, tooth must be moistened, since drying of enamel also changes the natural color of hard tooth tissues. Different areas of tooth have different shades and diff ent transparency, so when carrying out aesthetic restoration, materials of different shades and degrees of transparency are combined. Modern light-curing composite materials are available in sets, consists of the shades of "Enamel", which correspond to the transparency of tooth enamel, "Dentin", or "Opague", imitating opaque of dentin, as well as "Incisal edge", which has increased transparency and translucency.

3. *Isolation of the tooth from saliva.*
4. P*lacement and fixing of matrix.* Missing aproximal wall and contact point in the class III carious cavity should be restored during filling. To do this, the light-transmitting matrix is introduced into interdental space (Fig. 6.41), fixed with light-conducting wedges for vectorial polymerization. It is advisable to slightly wedge out the adjacent tooth, so that a tight contact point will be formed after filling and removal of the matrix between them.
5. *Preparation of the carious cavity for filling* (antiseptic treatment, drying). After the end of preparation, carious cavity should be thoroughly washed with distilled water, air-water spray and dried with air jet. Then treat walls and bottom of the carious cavity with 2 % solution of chlorhexidine biglu- conate for 30–60 seconds and dry with air jet.
6. *Placement of an insulating cap.* Using modern adhesive systems, in case of middle caries in permanent teeth with fully formed root, an insulating cap

should not be applied. The hybrid layer of dentin provides reliable isolation of the pulp from unfavorable influence of filling material components and bacterial invasion. In the case of deep carious cavity and during caries treatment in perma- nent teeth with unformed root, a minimum amount of calcium-sa- licylate cement should be applied to the part of carious cavity bottom corresponding to the projection of pulp horn and covered with a thin layer of glass-ionomer cement (pref- erably hybrid). Insulating cap is ap- plied only to the bottom of the car- ious cavity without transition to its walls.

7. *Application of adhesive system*. Be- fore applying the adhesive system, hard tooth tissues are etched with 37 % orthophosphoric acid (gel or solution). Adjecent tooth should be protected with matrix from getting acid on the intact enamel. Adhesive filling technique involves applying of the adhesive system to enamel, dentin and insulating cap.

Adhesive system is used according to the manufacturer's instructions.

Fig. 6.41. *Transparent celluloid matrix to protect front teeth: a – of anatomical form; b – of adhesive form*

8. *Portioned placement, condensation and polymerization of composite*. Light-curing composite material is placed into the carious cavity in portions (increments) with thickness not more than 1.5–2 mm, taking into account the vectorial polymerization. Each layer is polymerized separately. When filling the class III carious cavity, dentin is restored with dentine shades of filling material, enamel in the area of approximal walls and contact point – with enamel shades (Fig. 6.42).
9. *Final contouring, finishing and polishng of restoration*. Finishing and

pol- ishing of fillings are important steps of the tooth restoration. Their quality

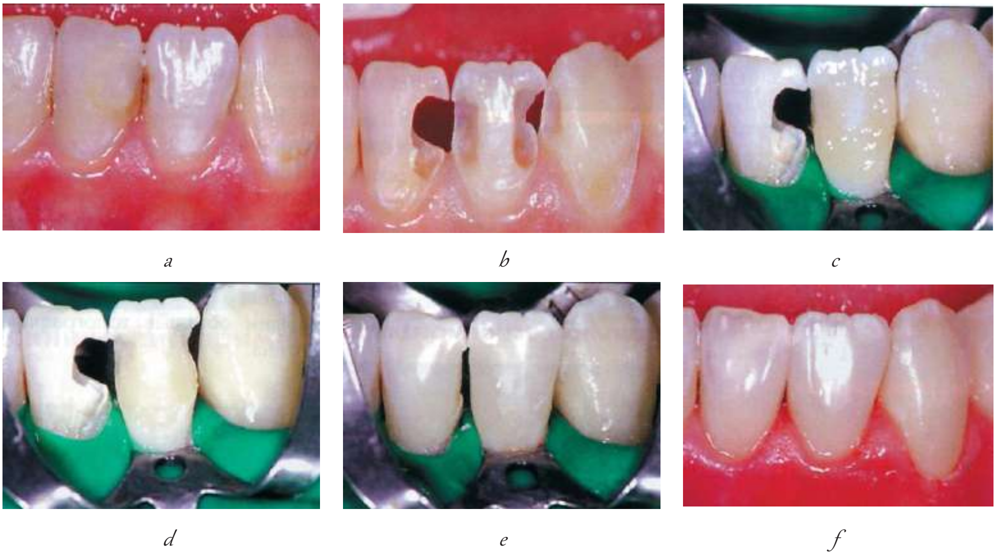


Fig. 6.42. Filling of the class III carious cavities in permanent mandibular incisors with light curing composite material: *a* – view of the lower incisors before treatment; *b* – view of the carious cavities on approximal surfaces of 31 and 32 incisors after preparation; *c* – application of the opaque shade to restore the main mass of dentin in 32 tooth; *d* – application of the enamel shade to restore vestibular surface of 32 tooth; *e* – restoration of the main mass of dentin in 31 tooth; *f* – view of 31 and 32 teeth after filling (Radlinsky S. V., 1998)

influences not only the final result, but also the preservation of aesthetic look of the restoration for a long time. The final treatment of filling consists of several steps:

– macro-contouring – correction of the restoration form taking into account anatomical shape of a tooth and occlusal relations. Macro-contouring is performed using turbine diamond heads with air-water cooling. Control of occlusive relations is carried out with special occlusive paper;
– micro-contouring is creating of a smooth restoration surface. This manipulation is performed using 10–12-faced carbide burs or diamond heads with fine grain (yellow or white mark), turbine handpiece with air-water cooling;
– finishing and polishing is carried out in order to create a perfectly smooth and shiny surface of restoration, imitating the shine and smoothness of natural tooth enamel. Polishing heads and discs of various degrees of abrasiveness are used for grinding and polishing of composite restorations. Sometimes silicone polishing cups with polishing pastes of various abrasiveness are used. Contact surfaces of restorations are ground and polished with abrasive fiinishing strips.

10. *Recommendations to a patient.* After tooth restoration with composite ma-

terials, a patient should not use products that can change the color of restoration – strong coffee, tea, red berries, red juices, etc. After 2–3 days it is recommended to conduct a control examination of patient's teeth and assess the state of restoration.

Steps of filling the class III carious cavity with self-curing composite material:

– isolation of the tooth from saliva;
– matrix placement and fixing. The plastic transparent matrix is placed into interdental space and fixed with light-transmitting wedges. It is advisable to slightly wedge an adjacent tooth, so that the tight contact point is formed after filling and matrix removing.
– preparation of the carious cavity for filling (antiseptic treatment, drying);
– if necessary, apply medicated / insulating caps. Medicated cap is applied on the bottom of carious cavity pointwise in the projection of pulp horn only. The insulating cap should cover medicated cap and entire dentine surface.
– etching the tooth enamel only with 37 % orthophosphoric acid (gel or solution) for 15–30 seconds;
– washing of the carious cavity with water jet for 30–60 seconds;
– drying of the carious cavity with gentle stream of air. After acid etching saliva or blood should not enter the carious cavity;
– preparation and application of adhesive system. The adhesive system is prepared by mixing of basic and catalytic liquids in the ratio of 1:1. With foam sponge adhesive system is applied to the enamel only (20 s) and air jet evenly distributes it over enamel surface (5 s);
– preparation of the filling mass of composite by mixing equal parts of basic and catalytic pastes, which are in the material set, for 30−40 s;
– placement of the self-curing composite material into carious cavity is carried out in one-two portions with a small excess, contouring of filling is performed using matrix;
– modeling of the filling surface and removal of non-polymerized surface layer (oxygen inhibited layer) is carried out after complete setting of material and removal matrix from interdental space;
– finishing of the filling is carried out with special accessories for composite materials.

Technique of filling the class III carious cavity with compomers

Compomers are available in specific color scheme, it allows you to choose the desired color and meet aesthetic requirements for restoration. Compomers can be used for filling the class III carious cavities in both permanent and primary teeth.

Steps of filling the class III carious cavity with compomer:

- isolation of the tooth from saliva;
- application and fixation of transparent matrix in the interdental space;
- preparation of the carious cavity for filling (antiseptic treatment, drying);
- application of medicated / insulating caps (if necessary);
- application of the adhesive system on walls and bottom of the carious cavity and its polymerization;
- portioned placement of the compomer of appropriate color into the carious cavity and its polymerization. The compomer layer can be up to 4–5 mm thick. This allows to fill the small carious cavities with one portion of material, reduces the time of filling and is convenient when working with children;
- removal matrix and additional polymerization of the contact surface of filling;
- contouring of compomer filling and its finishing are the same as when working with composite materials.

Technique of filling the class III carious cavity with glass-ionomer cement

Glass-ionomer cement can be used for filling of the class III cavities in primary teeth. Glass-ionomer cement is used for filling of the class III carious cavities in permanent teeth in children in the case when carious cavity is small and vestibular enamel is completely preserved. It ensures an aesthetic look of restoration.

Steps of filling the class III carious cavity with glass-ionomer cement:

- isolation of the tooth from saliva;
- placement of a retraction cord into the tooth-gingival furrow (if necessary);
- application and fixation of matrix in the interdental space. Both transparent and metal matrix can be used;
- preparation of the carious cavity for filling (antiseptic treatment, drying);
- application a medicated cap (if necessary);
- conditioning of hard tooth tissues, if it is provided by the instruction to GIS. Dentin conditioner (10–25 % solution of polyacrylic acid) is applied to bottom and walls of the carious cavity and washed off with water after 20–30 seconds;
- mixing of glass-ionomer cement on a pad with plastic spatula. Mix powder with liquid in proportions written in the instruction for filling material;
- placement of the cement mass into carious cavity in one portion;
- condensation of cement in the carious cavity (slightly moistened cotton ball may be used);

– modeling the surface of filling with carver (to prevent adhesion of cement mass, it is advisable to prelubricate the tool with special gel);
– remove matrix and retraction cord after hardening of material (in 4–5 min after start of mixing),
- minimal contouring of the filling surface with diamond heads;
– isolation of the filling from saliva for 24 hours with special varnishes ("Ketac Glaze" (3M ESPE), "Final Varnish" (VOCO), etc.);
– finishing and polishing of the filling in 24 hours after its application with diamond heads and polishing discs.

If glass-ionomer cement with the mechanism of light hardening is used for filling, the cement mass is placed into carious cavity with a certain excess. The filling is contoured using matrix, then it is polimerized with curing lamp for 40
s. After hardening of material, final finishing and polishing of the fillings surface, its covering with insulating varnish are conducted.

FILLING OF THE CLASS IV CARIOUS CAVITIES IN PRIMARY AND PERMANENT TEETH

Composite filling materials, compomers or glass-ionomer cement can be used for filling of the class IV carious cavities in primary teeth. Choice of filling mate- rial is influenced by possibility of cooperation with a child, since the technology of composite materials placement is quite time-consuming and requires dry oper- ating field. Therefore, composite filling material can be used in children under the condition of high level of cooperation between a child and a doctor. To speed up a work, special celluloid (transparent) caps can be used to restore the anatomical shape of primary tooth.

Hybrid composite filling materials are the material of choice in permanent teeth in children for filling the class IV carious cavities due to their strength and high aesthetic characteristics. The following factors should be considered before restoration: occlusal disorders, which can cause additional stress on the resto- ration, relationships with antagonistic teeth, which can limit space for restored tooth, as well as anomalies of the frontal teeth location. If these factors are not taken into account, a significant load on restoration can lead to its partial or com- plete destruction.

Technique of filling the class IV carious cavity with a composite materials

The complexity of filling the class IV carious cavities is need to restore incisal edge and especially angle of the crown.

Steps of filling the class IV carious cavity with light-curing composite mate- rial (Fig. 6.43):

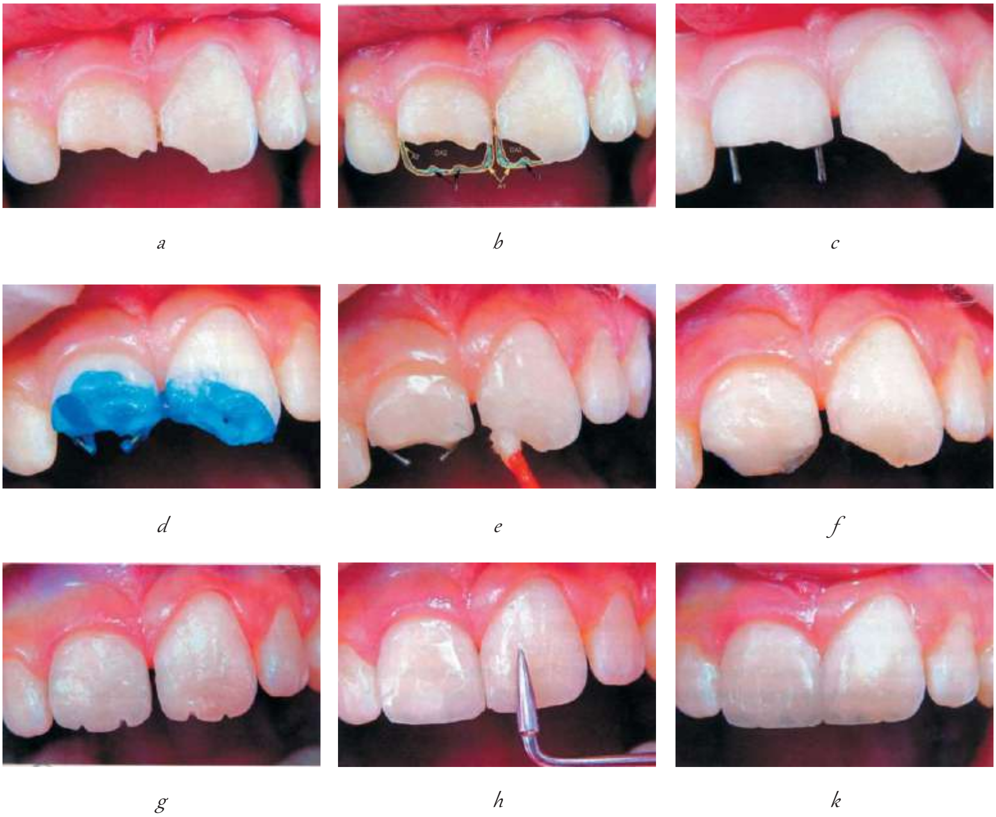


Fig. 6.43. *Steps of crown angle restoration in the 21 tooth and anatomical shape restoration of the crown in 11 tooth with light-curing composite material: a – view of 21 and 11 teeth before treatment; b – preliminary planning of restoration; c – parapulpar pins are installed in the 11 tooth; d – etching of hard tooth tissues; e – application of an adhesive; f – formation of the basis of restoration with opaque shade of composite material; g – modeling of the incisal edge; h – formation of the vestibular surface of restoration; k – view of 11 and 21 teeth after restoration (Lutska I. K., Novak N. V., 2009)*

- *cleaning of the tooth surface* with manual and mechanical tools designed to remove dental deposits, as well as polishing heads, end round and conical- brushes with abrasive pastes that do not contain fluoride;
- *planning of restoration* and selection of the shade of restorative material. When planning restoration, the anatomical features of tooth and its occlu- sal relationships, the topography of contact points are evaluated, the main shade of tooth and shades of other parts of its crown (neck, contact surfac- es, incisal edge) are determined. Determining of tooth color and selection of the shades of filling material are carried out with “Vita Shade” scale.

Determination of tooth color should be done before preparation of hard tooth tissues in daylight or artificial (daylight lamps) lighting. The tooth should be moistened. In process of restoration the class IV hard tooth tissues defect, it is necessary to restore the natural shade and transparency of all tooth tissues. It is known that tooth have three color zones: neck area, tooth body (primary color) and incisal edge area. The pregingival section has a bit darker shade (yellowish or grayish), its transparency is reduced. Therefore, preference is given to dentin shades when restoring the precervical region of tooth. Tooth body corresponds to the main color of enamel. Therefore select the necessary shade of filling material, focusing on it. Incisal edge is lighter and transparent area, can be of grayish or bluish shade;

– *isolation of the tooth from saliva*.
- *placement and fixation transparent matrix* in the interdental space;
– *preparation of carious cavity for filling* (antiseptic treatment, drying); Carious cavity should be well washed with distilled water after the end of preparation and dried with air jet. Then treat walls and bottom of the carious cavity with 2 % solution of chlorhexidine bigluconate for 30–60 seconds and dry them with an air jet.
– *application of a cap*. In case of middle caries in permanent teeth with fully formed root an insulating cap is not applied due to using of modern adhesive systems. In the case of deep carious cavity and treatment of dental caries in permanent teeth with unformed root, a minimum amount of calcium-salicylate cement should be applied to the bottom of carious cavity corresponding to the pulp horn projection and covered with a thin layer of glass-ionomer cement (preferably hybrid). Insulating cap is applied to the bottom of carious cavity only, without transition to its walls;
– *application of adhesive system*. Before applying an adhesive system, hard tooth tissues are etched with 37 % orthophosphoric acid (gel or solution). Adjacent tooth should be protected with matrix from getting acid on the intact enamel. In case of adhesive filling technique, an adhesive system is applied to enamel, to dentin and to insulating cap. Adhesive system is used according to the manufacturer’s instruction;
– *portioned placement, condensation and polymerization of composite* filling material. Light-curing composite filling material is placed into carious cavity in portions (increments) with the thickness not more than 1.5–2 mm, taking into account the vectorial polymerization. Each layer is polymerized separately. When filling the class IV carious cavity, dentin is restored with Dentin opaque material (combination of several shades is possible – darker in precervical area, lighter − in tooth body area). Incisal edge is restored with the transparent Incisal shade, anatomical shape of tooth is restored with Enamel shades, taking into account the color transition. In most cases 1–2 opaque shades, 1–2 enamel and 1 transparent shades are needed for aesthetic restoration of the class IV carious cavity;

– r*estoration of the anatomical shape of tooth* begins with formation of the lingual surface with opaque shade, ensuring its contact with adjacent tooth. Restoration is carried out in layers, each layer is polymerized for 20 sec- onds from vestibular and oral sides. Contour is not led by 0.5 mm on the vestibular surface for the enamel filling mass, which is applied with a small excess, taking into account the further final processing of filling;
– *final processing of restoration.* Removal of material excess and macrocon- touring of restoration is carried out with diamond heads or carbide burs. Coarse-grained grinding discs can be used to treat the vestibular surface and incisal edge. Thin grinding strips are used for finishing of the contact surface while watching the safety of approximal contact. Occlusive con- tacts should also be evaluated and grinding should be performed if neces- sary. Polishing of restoration to glossy surface is carried out with polishing pastes. Strips and dental floss are used to polish the approximal surfaces of filling;
– *recommendations to a patient*. After tooth restoration with the composite material a patient should not use products that can change the color of restoration – strong coffee, tea, red berries, red juices, etc. It is recommended to conduct control examination of patient's teeth and assess the restoration after 2–3 days.

Steps of filling the class IV carious cavity with self-curing composite material:
– *isolation of the tooth from saliva.*
– *placement and fixing of transparent matrix*. Apply transparent matrix into interdental space and fix it with wedges. It is advisable to slightly wedge an adjacent tooth, so that the tight contact point is formed after filling and matrix removing.
It should be noted that to recreate anatomical shape of the tooth – crown angle and incisal edge – is quite difficult with matrix only, so it is better to use special celluloid caps corresponding to anatomical shape of the tooth;
– *preparation of the carious cavity for filling* (antiseptic treatment, drying);
– application a medicated / insulating caps (if necessary); a medicated cap is applied to the bottom of carious cavity pointwise, in the pulp horn projection only. Insulating cap should cover medicated cap and entire dentin surface up to the enamel-dentin connection;
– *etching the tooth enamel only* with 37 % orthophosphoric acid (gel or solution) for 15–30 seconds;
– *rinsing of the carious cavity* with water jet should be twice as longer as the time of etching of hard tooth tissues (30–60 s);

- replacement of cotton rolls, *drying carious cavity* with weak air jet (10–20 s). Saliva or blood should not enter the carious cavity after acid etching;
- *preparation and application of adhesive system*. Adhesive system is prepared by mixing of basic and catalytic fluids in the ratio of 1 : 1. Adhesive system is evenly applied to enamel only with a foam sponge and slightly dried (5 s) with air to evenly distribute it over the enamel surface;
- *preparation of composite filling mass* by mixing of base and catalytic pastes in the equal parts;
- *placement the self-curing composite material* into carious cavity in one or two portions with a small excess, contouring of the filling with matrix. If celluloid caps are used for restoration, the prepared mass of filling material is introduced into a cap, which is put on the tooth and pressed. Excess of filling material in pregingival area should be removed with carver before it begins to harden;
- *final contouring* and removal of underpolymerized surface layer of the material, removal of matrix from the interdental space or cap;
- *finishing of the filling* with special accessories for composite materials.

If there are significant defects of incisal edge and angle of the crown, parapulpar pins can be used. They form additional retention points for fixing filling material in the carious cavity. To do this, artificial channels in the hard tooth tissues are drilled with a thin fissured or special drills parallel to the root canal. It is necessary to pay attention to the topography of tooth cavity, so as not to damage the pulp. Parapulpar pins are fitted in prepared channels so that their ends do not reach the edges of carious cavity by 0.5–1.0 mm. Fitted pins are fixed in the artificial channels with phosphate cement or glass-ionomer cement. An insulating cap is applied and carious cavity is filled using matrices and caps.

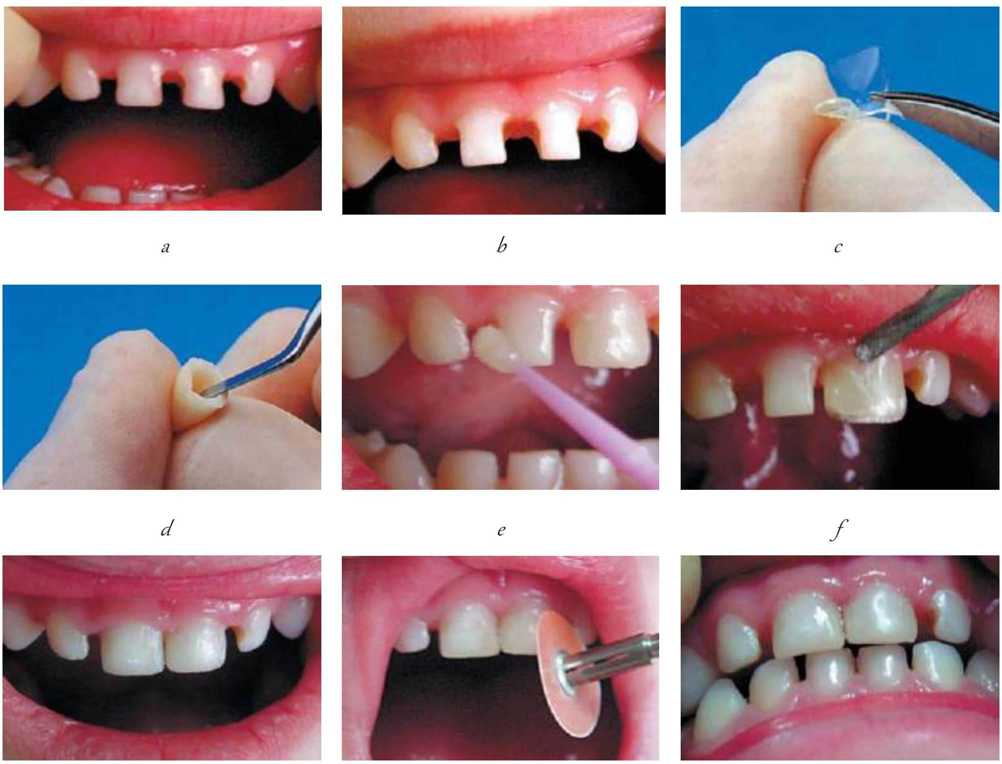
Standard celluloid caps in the form of dental crowns (strip-crowns) can be used for restoration of frontal primary teeth with modern composite filling materials. They are available as a 3M Strip Crown Kit (3M ESPE). Both hybrid and microfilled composites can be used for restoration with caps.

Indications for use of the caps:

- incisors with significant approximal defects;
- incisors after endodontical treatment;
- incisors after fractures, accompanied by a significant loss of hard tooth tissues;
- incisors with multiple hypoplastic defects or other defects of hard tooth tissues development;
- an unsatisfactory change of color of incisors;
- incisors with minor approximal defects, in the presence of large areas of pregingival demineralization.

Steps of primary tooth restoration with celluloid cap (Fig. 6.44):

– selection of the celluloid cap of desired size. To do this, tooth is measured with caliper in the medial-distal direction, then the cap is tried on to incisal edge;
– removal of all tooth tissues affected by caries using spherical drill and me- chanical handpiece;
– special preparation of teeth for restoration with caps consists in shortening of the crown part of primary tooth by preparing the incisal edge by 1.5 mm with diamond head and turbine handpiece. Crown becomes the conical shape by preparing of approximal surfaces to thickness of 0.5–1.0 mm. The vestibular wall is ground to 0.5–1.0 mm, and the lingual – 0.5 mm. The preginginval edge should have a protrusion (Fig. 6.44, *b*);
– color matching of restoration. If a tooth is changed in color, the color is selected by focusing on the adjacent tooth or lower incisor;



a *b* *c*

d *e* *f*

g *h* *k*

Fig. 6.44. *Steps of restoration of the primary tooth with celluloid cap: a – view of teeth before restoration; b – preparation of primary teeth for the caps; c – correction the length of the cap; d – application of an adhesive system; e – filling the cap with composite filling material; f – removal the celluloid cap with a carver; g – view of the restoration after removal of the cap; h – finishing treatment of restoration; k – final appearance of primary teeth after the end of restoration*

- celluloid caps are carefully cut with small curved scissors and carefully adapted to the pregingival area (Fig. 6.44, *c*);
- cut celluloid caps are tried on the prepared incisors. You should carefully check the length of cap and its fit to the tooth neck. Properly tight-fitting cap should go 1 mm under the gum and have the height approximately equal to height of adjacent tooth. Small through holes are made in medial and distal corners of incisal edge of the cap for exit of air and excess of fill- ing material;
- composite material is introduced into the cap, making recess in the middle to eliminate excess of material (Fig. 6.44, *d*);
- within 1 min, the prepared tooth is etched, washed and dried;
- application of an adhesive system, polymerization according to the instruction (Fig. 6.44, *e*);
- the cap, filled with a composite on 2/3, is tightly stuck to prepared tooth. Care should be taken in order to prevent deformation of the cap with excessive pressure. The excess of composite material in precervical region is removed using a probe, a carver or a modeling dental spatula;
- composite material is polymerized from vestibular and oral sides according to the instruction;
- an excavator or a carver is inserted under the edge of celluloid cap and cap is removed from the tooth after polymerization of filling material. The restoration is finished using flexible discs (Soflex, 3M ESPE) and diamond heads for the high-speed handpiece (Fig. 6.44 *f, g, h, k*).

Thus, Strip crowns are fast, simple and effective method of the restoration of primary incisors.

FILLING OF THE CLASS V CARIOUS CAVITIES IN PRIMARY AND PERMANENT TEETH

Composite filling materials, compomers, silver amalgam and glass-ionomer cement are used for filling of the class V carious cavities in permanent teeth in children. Glass-ionomer cement, compomers, less often zinc-phosphate cements are used for this purpose in primary teeth. The choice of filling material and technique of filling of the class V carious cavity in children depends on the stage of permanent or primary tooth development, as well as on the depth of carious cavity.

In primary teeth at the stage of root formation glass-ionomer cement is used mainly for filling of the class V carious cavities, taking into account the relatively simple filling technique and anti-carious properties of these filling materials. In primary teeth at the stage of root stabilization along with glass-ionomer cements compomers and composite filling materials can be used, especially in the case of good cooperation of a child with a doctor.

For filling of the class V carious cavities in permanent teeth in children glass-ionomer cements, composite materials, compomers are used. Silver amalgam can be used in the lateral parts of dental raw.

When filling the class V carious cavities in permanent teeth with incomplete root formation, taking into account the large volume of tooth cavity and close location of the pulp to carious cavity bottom, medicated caps are often used in order to prevent development of the pulp complications. Medicated cap should be overlapped with an insulating cap.

Technique of filling the class V carious cavity with glass-ionomer cement

Glass-ionomer cements due to their positive properties − high adhesion with hard tooth tissues due to formation of chemical bond, anticarious action due to prolonged release of fluoride, relatively simple technique of work are widely used in practice of pediatric therapeutic dentistry for filling of the class V carious cav- ities in both primary and permanent teeth. When filling of the class V carious cavities in lateral teeth, glass-ionomer cements can be an alternative to compos- ites since the masticatoryl load on the filling is insignificant and there are no high aesthetic requirements.

Steps of filling of the class V carious cavity with glass-ionomer cement:

- isolation of the tooth from saliva;
- placement of a retraction cord into the tooth-gingival furrow;
- preparation of the carious cavity for filling (antiseptic treatment, drying);
- application a medicated cap (if necessary);
- conditioning of hard tooth tissues, if it is provided by the instruction to glass-ionomer cement. To do this, special dentin conditioner (10–25 % solution of polyacrylic acid) is applied to the bottom and walls of carious cavity and after 30 seconds it is washed off with water for 1 min;
- replacement of cotton rolls, drying of the carious cavity;
- mixing of glass-ionomer cement on a paper block with plastic spatula, thorough mixing of powder with liquid in proportions specified in the instruction for the filling material;
- placement of the cement mass into carious cavity in one portion;
- condensation of cement in the carious cavity (you can use a slightly moistened cotton ball);

– contouring of the filling surface is advisable to conduct with standard cervical matrix. The matrix should be held until the material loses its gloss (at least for 4–5 minutes);
– isolation of filling from saliva for 24 hours using varnishes: “Ketac Glaze” (3M ESPE), “Final Varnish” (VOCO), etc. For the same purpose, Unfilled composite, which should be polymerized for 20 s , can be used for the same purpose;
– final processing of the filling after 24 hours with diamond heads and polishing discs.

If glass-ionomer cement with the mechanism of light hardening is used for filling, the cement mass is introduced into carious cavity with a certain excess. After that, it is polymerized with a curing lamp for 40 s. After solidification of the material, the final processing and polishing of the filling surface is carried out, it is covered with an covering varnish.

Technique of filling of the class V carious cavity with composite filling materials

Taking into account the high aesthetic properties of composite filling materials, they are most often used for filling of the class V carious cavities in permanent teeth, especially if they are located in the frontal part of a dental raw. When filling of the class V carious cavities in primary teeth, these filling materials can be used in case of good cooperation of a child with a doctor and the possibility of provid- ing dry working field. When filling of the class V carious cavities, it is advisable to use microfilled composites due to their good polishing ability, which ensures an optimal compliance of filling with the color of the tooth. The lower stiffness compared to hybrid composites is an advantage, since the filling in precervical region of microfilled composite is more resistant to bending.

When choosing a color, it is better to use two shades, if the filling passes through two color zones of tooth (from the gum to incisal edge). Dentin (opaque) colors are more suitable for the precervical area.

Steps of filling the class V carious cavity with light-curing composite filling material:

– isolation of the tooth from saliva;
– placement of a retraction cord into the tooth-gingival furrow;
– preparation of the carious cavity for filling (antiseptic treatment, drying);
– application a medicated / insulating cap (if necessary) of glass-ionomer (zinc-phosphate or polycarboxylate) cement;
– etching of the hard tooth tissues with 37 % orthophosphoric acid (gel or

solution). Enamel only or enamel and dentin (total etching) are etched for 15–30 seconds, depending on the type of an adhesive system;

– rinsing of the carious cavity with water jet for the time twice as long as etching time (30–60 s);
– drying of the carious cavity with weak stream of air. After acid etching, saliva or blood should not enter the carious cavity;
– application of adhesive system (20 s), its distribution along walls and bottom of the carious cavity with weak air jet (5 s) and polymerization (20 s);
– portioned placement, condensation and polymerization of composite filling material;
– final contouring of the filling surface using diamond heads and burs;
– finishing of the filling (polishing to a "mirror shine" of dry surface) with special accessories designed for processing of composite filling materials (burs, finishers, polishing discs, polishing pastes of different grain, etc.).

Steps of filling of the class V carious cavity with self-curing composite filling material:

– isolation of the tooth from saliva;
– placement of a retraction cord into the tooth-gingival furrow;
– preparation of the carious cavity for filling (antiseptic treatment, drying);
– application of therapeutic / insulating cap (if necessary) of glass-ionomer (zinc-phosphate or polycarboxylate) cement;
– etching of the tooth enamel only with 37 % orthophosphoric acid (gel or solution) for 15–30 seconds;
– rinsing of the carious cavity with water jet for the time twice as long as etching time (30–60 s);
– drying of the carious cavity with weak stream of air. After acid etching, saliva or blood should not enter the carious cavity;
– preparation and application of the adhesive system. Mixing of its components is carried out in the ratio of 1:1 in special plates with grooves. Enamel is treated with prepared adhesive (20 s) using special foam sponge or small cotton bal. Then it is slightly dried with weak air jet (5 s) to evenly distribute adhesive on the etched surface;
– preparation of the composite material on paper block by mixing of base and catalytic pastes in the equal parts with plastic spatula to dough-like consistency of uniform color;
– placement of the self-curing composite material into the carious cavity in one or two portions with a small excess. Special cervical matrices can be used to modeling the filling surface in pregingival area;

– final modeling of the filling surface and removal of the non-polimerized surface layer (oxygen inhibited layer) after complete solidification of the material;
– finishing of the filling (grinding and polishing) with special accessories for composite materials. It is unacceptable to leave overhanging edge of the filling, because it can cause inflammation of gums – gingivitis.

Technique of filling the class V carious cavity with compomers

Compomers are available in a certain color scheme, which allows to choose the right color and meet aesthetic requirements of restorations. Compomers do not require preetching of enamel, and it simplifies the technique of working with them to a certain extent.

Steps of filling class V carious cavity with compomers:
– isolation of the tooth from saliva;
– placement of a retraction cord into the tooth-gingival furrow;
– preparation of the carious cavity for filling (antiseptic treatment, drying);
– application a medicated/insulating cap (if necessary) of glass-ionomer (zinc-phosphate or polycarboxylate) cement;
– application of an adhesive system (20 s) on walls and bottom of the carious cavity, its uniform distribution on walls and bottom of the carious cavity with weak air jet (5 s) and polymerization (20 s);
– portioned placement of the filling material into carious cavity, its condensation and polymerization. The compomer, unlike composite, can be introduced into carious cavity in one portion, which reduces the time of filling and is convenient when working with children;
– contouring of the filling and its finishing are carried out as well as when working with composites.

Technique of filling the class V carious cavity with amalgam

Silver amalgam, taking into account its strength, mechanical stability and moderate sensitivity to moisture, can be used for filling the class V carious cavities, located in molars of upper or lower jaws, since aesthetic requirements are not the main ones.

Steps of filling the class V carious cavity with silver amalgam:
– isolation of the tooth from saliva;
– placement of a retraction cord into the tooth-gingival furrow;
– preparation of the carious cavity for filling (antiseptic treatment, drying);
– application a medicated and an insulating caps. Application of insulating

cap is the obligatory step in the filling of carious cavity with amalgam. The insulating cap for amalgam filling can be made of zinc-phosphate, poly- carboxylate or glass-ionomer cement. The amalgam has high coefficient of thermal conductivity, so in case of absence an insulating cap, thermal irri- tation of pulp can occur and may cause complications after filling;

- preparation of amalgam mass in amalgam mixer;
- portioned placement of freshly prepared amalgam into carious cavity using amalgam carrier or amalgam syringes;
- thorough compaction of amalgam in the carious cavity (condensation) using special plugger with cutting on the working part – the amalgam carrier. Each portion of amalgam is carefully lapped to the walls and bottom of the carious cavity with circular movements,;
- final processing of the filling (grinding and polishing) with special accessories for amalgam fillings is carried out not earlier than after 24 hours.

Control questions

1. What are the main steps of filling of the carious cavity?
2. What requirements should the materials for insulating caps meet? For what purpose are they used? What dental materials can be used as insulating caps?
3. In what cases is it necessary to use a medicated cap? What requirements should it meet? What materials are used as medicated caps?
4. List steps of filling of the carious cavity with glass-ionomer cements.
5. List steps of filling of the carious cavity with amalgam.
6. List steps of filling of the carious cavity with self-curing composite material.
7. List steps of filling of the carious cavity with light-curing composite material.
8. List steps of filling of the carious cavity with compomers.
9. What accessories the contact point is restored with? What types of matrices do you know? Describe the technique of contact point restoring.
10. What is the “conouring, finishing and polishing of the filling”? With what tools and how is it performed?

Algorithm for applying the Zinc-phosphate cement (ZPC) insulating cap to the classes I-V carious cavities

Material supply:
- dental unit;
- cotton rolls;
- saliva ejector;
- kit of dental instruments (probe, mirror, tweezers, excavator, metal spatula, plugger, carver);
- slide glass plate;
- zinc-phosphate cement.

Algorithm to perform dental procedures

N	Action sequence	Criteria for control of correct execution
1	Isolate the tooth from saliva using cotton rolls and saliva ejector	Tooth is not in contact with saliva
2	Perform antiseptic treatment of the carious cavity	Carious cavity is clean, does not
3	Dry out the carious cavity for 10–20 seconds	Carious cavity is dry
4	Put glass plate (smooth side up) on the table to mix filling	Glass plate is clean and dry
5	Apply 3 drops of the liquid to glass plate. The bottle with liquid	Compliance with the optimal ratio of powder
6	Shake the bottle several times before taking powder. Measure 2 portions of powder with measuring spoon included in the set.	Compliance with optimal ratio of powder and liquid for ZPC (2 : 3)
7	The measured amount of powder should be divided into parts: 1/4,	Compliance with clear powder
8	Mix the first 1/4 of powder with liquid using a metal spatula for	Observance of the mixing time. The mass
9	Subsequently add other 1/4, 1/4, 1/8, 1/16, 1/16 portions of powder to the homogeneous mass and mix them thoroughly for 30-60 s	Compliance with mixing time (for ZPC on average it is 1–1.5 minutes). The mass should be uniform, not to stretch for a spatula, and come
10	Placement of filling mass into carious cavity with a carver in one portion. Carefully condense it with a plugger to the bottom and walls of the carious cavity. Remove the remaining mass with an excavator. The application time of insulating cap should not be	Compliance with working time (for ZPC on average it is 2–3 minutes). The insulating cap evenly covers the bottom and walls of the carious cavity to enamel-

11	After hardening of the insulating cap, a permanent filling material should be introduced into the carious cavity.	The Insulating cap is solid

Algorithm for applying the Zinc-polycarboxylate cement insulating cap to the classes I-V carious cavities

Material supply:

– dental unit;
– cotton rolls;
– saliva ejector;
– kit of dental instruments (probe, mirror, tweezers, excavator, metal spatula, plugger, carver);
– slide glass plates;
– polycarboxylate cement.

Algorithm to perform dental procedures

N	Action sequence	Criteria for control of correct execution
1	Isolate of the tooth from saliva with cotton rolls and apply	The tooth is not in contact with saliva
2	Perform antiseptic treatment of the carious cavity	Carious cavity is clean, does not
3	Dry out the carious cavity for 10–20 seconds	Carious cavity is dry
4	Put a glass plate on table (smooth side up) for mixing of filling	Glass plate is clean, dry
5	Apply 5 drops of the liquid to a paper or glass plate. A bottle with liquid should be held high so that drop falls freely	Compliance with optimal ratio of powder and liquid for ZnPCC (3: 5)
6	Shake the bottle several times before taking powder. Measure out 3 portions of powder wit the measuring spoon included in the set. Apply the powder to glass plate	Compliance with optimal ratio of powder and liquid for ZnPCC (3: 5)
7	The measured amount of powder is divided into 2 parts	Compliance with clear powder
8	Mix the first 1/2 of powder with liquid using a metal spatula for	Observance of mixing time. The mass must be
9	Add the second 1/2 part of powder to homogeneous mass and mix thoroughly for 20–30 seconds	Compliance with mixing time (for ZnPCC it is on average 30–40 seconds). The mass is homogeneous, thick, shiny and viscous

10	Introduce the filling mass into the arious cavity with a carver in one portion. Carefully condense it with a plugger to the bottom and walls of carious cavity. Remove remaining	Compliance with working time (for ZnPCC on average it is 2–3 minutes). The insulating cap evenly covers the bottom and walls of the
11	After hardening of the insulating cap, introduce permanent filling material into carious cavity. Hardening time for ZnPCC is on average	The insulating cap is solid
Note. Algorithm shows the average values of powder and liquid ratio, working time, as well as time of mixing and hardening of zinc-polycarboxylate cements. In different ZnPCCs the above-mentioned indicators can differ, therefore before		

Algorithm for applying a glass-ionomer cement insulating cap to the classes I–V carious cavities

Material supply:

- dental unit;
- cotton rolls;
- saliva ejector;
- kit of dental instruments (probe, mirror, tweezers, excavator, plastic spatula, plugger, carver);
- slide glass plates;
- glass-ionomer cement
- applicators for conditioner.

Algorithm to perform dental procedures

N	Action sequence	Criteria for control of correct
1	Isolate the tooth from saliva with cotton rolls, saliva ejector	The tooth is not in contact with saliva
2	Carry out an antiseptic treatment of carious cavity	The carious cavity is clean, does not contain
3	Dry out the carious cavity for 10–20 seconds, but do not overdry	The carious cavity should remain
4	Put a glass plate on a table (smooth side up) for mixing of filling	Glass plate is dry, clean
5	Apply the required amount of liquid to glass plate (according to the instruction). The bottle of liquid should be held high so that drop falls	Compliance with the optimal ratio of liquid and powder for GIC (the average is
6	Shake the bottle several times before taking powder. Measure the required amount of powder with a measuring spoon included in the material set (according to the instructions). Apply powder to glass plate	Compliance with the optimum ratio of liquid and powder for interlining GIC (average is 1.5: 1)

7	The measured amount of powder is divided into 2 parts	Compliance with a clear distribution of
8	Mix the first 1/2 of powder with liquid using a plastic spatula for 10–20 seconds	Compliance with time of mixing of the first portion. Homogeneous mass
9	Sequentially add 1/2 portion of powder to a homogeneous mass and mix thoroughly for 10–20 seconds	Compliance with mixing time (for GIC it is on average 30–40 seconds). The mass is
10	Placement the filling mass into the carious cavity with a carver in one portion. Remove the remains of mass with an excavator. The application time of insulating cap should not exceed	Compliance with the working time (for GIC it is 2 minutes on average). The insulating cap evenly covers the bottom and walls of
11	After hardening of the insulating cap, introduce permanent filling material into the carious cavity. The hardening time of GIC is 4–5	Insulating cap is solid

Note. The algorithm shows average values of powder and liquid ratio, working time, as well as time of mixing and hardening of glass-ionomer cements. These indicators may differ from one GIC to another, so you should read the instructions before

Algorithm for applying the medicated cap of salicylate (chelate) cements with calcium hydroxide to the classes I-V carious cavities

Material supply:

– dental unit;
– cotton rolls;
– saliva ejector;
– kitt of dental instruments (probe, mirror, tweezers, excavator, plastic spatula, plugger, carver).
– slide paper plates;
– salicylate cement with calcium hydroxide.

Algorithm to perform dental procedures

N	Action sequence	Criteria for control of correct execution
1	Isolate the tooth from saliva with cotton rolls, saliva ejector	The tooth is not in contact with saliva
2	Carry out an antiseptic treatment of the carious cavity	Carious cavity is clean, does not
3	Dry out the carious cavity for 10–20 seconds	The carious cavity is dry

4	Put the paper plate on a table to mix material	The paper plate is clean
5	Squeeze out from tubes paste No.1 and paste No.2 in the ratio 1 : 1 on a	Observance of uniform ratio of base and
6	Mix with a plastic spatula for 15 seconds	Observance of mixing time. The mass has a
7	Apply a small amount of material to the bottom of carious cavity in the pulp horn projection with a thin carver or probe. Remove the remaining mass with an excavator	Compliance with working time (for CCHC it is 3–5 minutes). A medicated cap is determined only in the projection of pulp horns
8	After hardening of the CCHC placement of medicated cap into the carious cavity. The hardening time is 0.5–1 min	The medicated cap is dense.
Note. The algorithm shows the average values of components ratio, working time, as well as time of mixing and hardening of chelated cements with calcium hydroxide. In different CCHCs the above- mentioned indicators can differ, therefore,		

Algorithm for filling the classes I-V carious cavities in temporary teeth with glass-ionomer cement

Material supply:

– dental unit;
– dental handpieces (turbine, mechanical);
– cotton rolls;
– saliva ejector;
– kit of dental instruments (probe, mirror, tweezers, excavator, plastic spatula, plugger, carver);
– slide paper and glass plates;
– glass-ionomer cement
– applicators for conditioner and covering varnish;
– retraction cord;
– matrix;
– wooden wedges;
– articulating paper;
– diamond heads, carborundum heads, abrasive discs, rubber heads for finishing and polishing of fillings, polishing paste.

Algorithm to perform dental procedures

N	*Action sequence*	*Criteria for control of correct execution*
1	Isolate of the tooth from saliva with cotton rolls, saliva ejector	Tooth is not in contact with saliva

2	When filling carious cavities of II, III, IV and V classes enter a retraction cord into the dental-gingival furrow with a carver	The pregingival wall of the carious cavity is separated from the gingival papilla and is fully accessible for visual inspection
3	When filling carious cavities of II, III and IV classes introduce a matrix into an interdental space and fix it with a wooden wedge. One edge of matrix is located under the gum, the other – at the	The matrix in correct position is fixed in an interdental space
4	Carry out an antiseptic treatment of the carious cavity	The carious cavity is clean, does not contain
5	Dry out the carious cavity for 10–20 seconds, but not overdry	The carious cavity should remain
6	If the material includes a conditioner, it is necessary to treat the carious cavity with an applicator for 10-30 seconds	Evenly distribute a conditioner along the bottom and walls of the carious cavity
7	Rinse the cavity with water for 20–60 seconds	The carious cavity does not contain
8	Dry out the carious cavity for 10–20 seconds, but not overdry	The carious cavity should remain
9	Put the glass plate a table (smooth side up) for mixing of filling	Glass plate is dry, clean
10	Apply a required amount of liquid to the glass plate (according to the instructions). The bottle of liquid should be held high so that drop falls freely	Compliance with the optimal ratio of powder and liquid for restoration GIC (in average 3 : 1)
11	Shake the bottle several times before taking powder. Measure the required amount of powder with the measuring spoon included in the material set (according to the instructions). Apply the	Compliance with optimal ratio of powder and liquid for restoration GIC (in average 3 : 1)
12	The measured amount of powder is divided into 2 parts	Compliance with uniform distribution of the
13	The first part of powder is quickly introduced into the liquid with a plastic spatula and mixed for 10–20 seconds	Compliance with the time of mixing of first portion. The mass must be homogeneous
14	Sequentially add 1/2 portion of powder to a homogeneous mass and mix thoroughly for 30–40 seconds	Observance of the mixing time (for GIC it is on average 30–40 seconds). The mass should be
15	Placement of the filling mass into the carious cavity with a carver in one portion. Carefully condense it with a plugger or a slightly wet small cotton ball. The modeling time of filling should not	Compliance with the working time (for GIC it is on average 2 minutes). The filling mass evenly fills entire carious cavity with a slight

16	Check the occlusion with articulating paper. Carry out preliminary processing (grinding) of a filling by means of carborundum heads and flexible abrasive disks after hardening ofa filling material: in 4–5 min	Grinding of fillings is started in 4–5 minutes. The filling reproduces anatomical shape of the tooth (occlusal, approximal or vestibular surfaces), has a smooth surface and does not
17	If the material includes a special insulating varnish, it should be applied to the filling with an applicator and evenly distributed	The filling has a shiny surface
18	Perform the final polishing of filling with a diamond heads, flexible abrasive discs, rubber heads with fine abrasive paste in the next visit (after 24 hours), that is, after final polymerization of the	The final treatment of filling is started in 24 hours. The filling has a smooth surface
19	Re-coat the filling with a special varnish using an applicator	The filling has a shiny surface
Note. The algorithm shows average values of the powder and liquid ratio, working time, as well as the time of mixing and hardening of glass-ionomer cements. In different GICs the above-mentioned indicators can differ, therefore before their		

Algorithm for filling the classes I-V carious cavities in temporary teeth with compomer materials

Material supply:

– dental unit;
– dental handpieces (turbine, mechanical);
– cotton rolls;
– saliva ejector;
– kit of dental instruments (probe, mirror, tweezers, excavator, plugger, carver).
– compomer materials;
– self-etching adhesive systems (of VI–VII generations);
– applicators for adhesive system;
– curing lamp, safety glasses;
– retraction cord;
– matrix;
– wooden wedges;
– articulating paper;
– diamond heads, abrasive discs, rubber heads for finishing and polishing of fillings, polishing paste.

Algorithm to perform dental procedures

N	Action sequence	Criteria for control of correct execution
1	Choose the filling material shade with the color scale in daylight. The surface of a tooth and the scale should be wet	The color of the tooth coincides with selected scale shade. The test portion of material applied to the tooth surface and polymerized coincides with the color of
2	Isolate the tooth from saliva with cotton rolls, saliva	The tooth is not in contact with saliva
3	When filling II, III, IV and V classes carious cavities insert a retraction cord into a dental- gingival furrow	The pregingival wall of the carious cavity is separated from gingival papilla and is fully accessible for a
4	When filling carious cavities of II, III and IV classes insert a matrix into interdental space and fix it with a wooden wedge. One edge of matrix is located under the gum, the	The matrix in correct position is fixed in the interdental space
5	Carry out an antiseptic treatment of the carious cavity	The carious cavity is clean, does not contain dentin
6	Dry out thecarious cavity for 10–20 s, but not overdry	The carious cavity should remain slightly
7	Mix components of self-etching adhesive system (for two-component systems of the VI generation). Apply an adhesive (for VI generation – 1 layer, for VII – 3 layers) to the bottom and walls of the carious cavity with an applicator and rub it for 20–30 seconds. Evenly distribute the adhesive with an air jet	Compliance with processing time and polymerization of self-etching adhesive system according to the instructions. The walls and bottom of the carious cavity are shiny, evenly covered with a thin layer of an adhesive system
8	Placement of the compomer material into the carious cavity with a carver. The thickness of each layer should not exceed 4–5 mm (according to the instructions). Carefully condense each portion of material with a plugger. Polymerize each portion for 40 s. Start polymerization from the side of carious cavity wall, to which this portion of material should	The compomer material equally fills entire carious cavity with a slight excess and fits tightly to the edges of enamel
9	Check occlusion with an articulating paper. Carry out a preliminary treatment (grinding) of filling using carborundum heads and flexible abrasive disks after	The filling reproduces the anatomical shape of the tooth (occlusal, approximal or vestibular surface), has a smooth surface and does not
10	Perform final polishing of filling with diamond heads, flexible abrasive discs, rubber heads with fine abrasive	The filling has a smooth shiny surface

Note. The algorithm shows average values of treatment time and polymerization of self-etching adhesive systems, as well as polymerization time of the compomer material. In different adhesive systems and compomer materials, the above mentioned indications may differ, so you should read instructions before using them.

Algorithm for filling the classes I-II carious cavities in permanent teeth with amalgam

Material supply:

– dental unit;
– dental handpieces (turbine, mechanical);
– cotton rolls;
– saliva ejector;
– kit of dental instruments (probe, mirror, tweezers, excavator, metal and plastic spatulas, amalgam carrier, special plugger with cutting, carvers);
– slide paper and glass plates;
– insulating cement (zinc-phosphate, polycarboxylate, glass-ionomer);
– amalgam;
– amalgam mixer;
– retraction cord;
– matrices, matrix holders;
– wooden wedges;
– articulating paper;
– carborundum heads, abrasive discs, burs, finishers, rubber heads for treatment and polishing of amalgam fillings, polishing paste.

Algorithm to perform dental procedures

N	Action sequence	Criteria for control of correct execution
1	Isolate of the tooth from saliva with cotton rolls, saliva ejector	The tooth is not in contact with saliva
2	Carry out an antiseptic treatment of the carious cavity	The carious cavity is clean, does not contain dentin chips
3	When filling class II carious cavities, insert a retraction cord into the tooth-gingival furrow with a carver	The pregingival wall of the carious cavity is separated from a gingival papilla and is fully accessible for visual inspection

4	When filling the class II carious cavities enter the matrix into an interdental space and fix it with a wooden wedge. One edge of the matrix is located under the gum, and the other – at the level of occlusal surface. The matrix is in close contact with	The matrix in correct position is firmly fixed in an interdental space
5	Dry the carious cavity for 10–20 seconds	The carious cavity is dry
6	Before filling the carious cavity with amalgam, it is necessary to apply an insulating cap of ZP or GIC, or Zn PC cements	The insulating cap is dense, uniformly covers the bottom and walls to the enamel-dentin
7	Place a capsule containing silver alloy powder and mercury in an amalgam mixer. Mixing time for different types of amalgam is from	Compliance with the mixing time of amalgam according to the instructions.
8	Add the first small portion of amalgam with an amalgam carrier into the carious cavity immediately after its mixing	You must start filling within the first minute after mixing of amalgam. Amalgam is introduced in a small
9	Carefully lap the first portion of amalgam to the bottom and walls of the carious cavity with circular movements using a special plugger	In case of correct execution of this manipulation, the amalgam creaks, its surface
10	Placement of the following portions of amalgam into the carious cavity. The size of each of them should not exceed 3–5 mm. Carefully condense each portion with a special plugger. Condensation of amalgam should begin from the center of	The amalgam filling tightly fills the carious cavity with a slight excess
11	Carry out rough modeling of plastic amalgam. Form the occlusal surface of filling in the process of modeling. Create pressure on the filling with an antagonist tooth. Remove a small layer of amalgam covering enamel alongthe edge of the filling with a sharp tool	The filling reproduces the anatomical shape of tooth: occlusal or contact surface.
12	Carry out the final processing of filling at the next visit. Check occlusion with an articulating paper. Carry out grinding with carborundum heads, abrasive discs and burs. Carry out polishing with burs, polishing rubber heads, soft brushes and polishing paste. During the final processing filling should be constantly moistened	The final processing of filling is started in 24 hours. The filling does not violate occlusal contacts. The filling reproduces anatomical shape of the tooth, fits tightly to the edges of enamel, has a smooth surface of a mirror gloss. When restoring class II carious cavities, the contact point is dense: a dental floss stays only in the
Note. The algorithm shows average values of amalgam mixing time. In different types of amalgam, the above mentioned indicators may differ, so you should read the instruction before using them		

Algorithm for filling the classes I-V carious cavities in permanent teeth (with unformed and formed roots) with self-curing composite materials

The material supply:

– dental unit;
– dental handpieces (turbine, mechanical);
– cotton rolls;
– saliva ejector;
– kit of dental instruments (probe, mirror, tweezers, excavator, plastic and metal spatula, pluggers, carvers);
– slide paper and glass plates;
– insulating cements (zinc phosphate, polycarboxylate, glass-ionomer);
– salicylate cements with calcium hydroxide for a medicated cap;
– self-curing composite materials;
– color scale;
– etching gel;
– adhesive system;
– applicators for adhesive system;
– retraction cord;
– matrices, matrix holders;
– wooden wedges;
– articulating paper;
– diamond heads, abrasive discs, strips, rubber heads for treatment and polishing of fillings, polishing paste;
– end round brushes, flosses, paste of average degree of abrasiveness without fluoride, indicators of a dental plaque;
– fluoride varnish.

Algorithm to perform dental procedures

N	Action sequence	Criteria for control of correct execution
1	Perform a professional cleaning of all tooth surfaces which is filled and adjacent teeth with flosses, end round brushes and abrasive	Tooth surfaces are not stained by plaque indicators
2	Choose the shade of filling material using the shade grade. Shade matching should be carried in natural daylight. The tooth and the shade grade should be wet	Color of the tooth coincides with the selected shade. The test portion of material corresponds to the color of the tooth
3	Isolate of the tooth from saliva with cotton rolls, saliva ejector	The tooth is not in contact with saliva

4	When filling classes II, III, IV and V carious cavities enter a retraction cord into the dental-gingival furrow with a carver	The pregingival wall of the carious cavity is separated from a gingival papilla and is fully accessible for visual inspection
5	When filling II, III and IV classes of carious cavities, insert a matrix into an interdental space and fix it with a matrix holder and a wooden wedge. One edge of the matrix is located under the gum, and the other – at the level of occlusal surface or incisal edge. The matrix	The matrix in the correct position is fixed in the interdental space
6	Perform an antiseptic treatment of the carious cavity	The carious cavity is clean, does not contain
7	Dry out the carious cavity for 10–20 seconds	The carious cavity is dry
8	In the case of acute deep caries in a formed permanent tooth and in cases of acute medium and deep caries in permanent teeth with unformed roots, apply a medicated cap of salicylate cement with calcium hydroxide to the bottom of carious	A medicated cap is dense, determined only in the projection of pulp horns
9	Before filling the carious cavity with a self-curing composite material, apply an insulating cap of ZP or GIC, or Zn PC cement	The insulating cap is dense, evenly covers bottom and walls of the carious cavity to the
10	Etch enamel with a gel with 37 % orthophosphoric acid for 15–30 seconds	The etching gel is applied only to enamel. Compliance with the enamel etching time
11	Rinse the carious cavity with water for 30–60 seconds to remove the etching gel	The carious cavity does not contain residues of etching gel
12	Replace cotton rolls with dry ones	The tooth is not in contact with saliva
13	Dry the carious cavity	The carious cavity is dry. The surface of properly etched enamel has acquired a chalky
14	Put a paper plate on ta able to mix an adhesive system and a filling material	The paper plate is clean
15	Apply 1 drop of basic and 1 drop of catalytic liquid of the adhesive system to the paper plate. Mix them with an applicator for 10–15	Compliance with the ratio of base and catalytic fluid of the adhesive system (1 : 1)
16	Apply the adhesive system to enamel surface using an applicator. Evenly distribute it with air jet for 10–20 seconds	Enamel surface is shiny and covered with a thin layer of the adhesive system

17	Apply 1 part of base and 1 part of catalytic paste of the composite material to paper plate using opposite ends of the plastic spatula	Compliance with the optimal ratio of basic and catalytic paste of the composite
18	Mix the composite material with plastic spatula for 20–45 seconds (according to the instruction)	Observance of the mixing time. The filling mass is homogeneous
19	Placement of the filling mass into the carious cavity in one or two portions. Carefully condense it with a plugger. The modeling time of filling should not exceed 1.5–2 min.	Compliance with the working time for self-curing composite materials (on average 2–3 minutes). The filling mass evenly fills the entire carious cavity with a slight excess and fits
20	Check occlusion with an articulating paper. Perform processing (grinding) of filling with diamond or carborundum heads, flexible abrasive discs and strips after the final hardening of the filling material (on average for 4–5 minutes)	Grinding of the fillings is started in 4–5 minutes. Filling does not violate occlusal contacts. The filling reproduces anatomical shape of the tooth, tightly adheres to the edges of enamel. When restoring classes II, III and IV carious cavities, the contact point is dense – a dental floss
21	Carry out the final polishing of fillings with diamond heads, flexible abrasive discs, strips and rubber heads with finely abrasive	The filling has a smooth surface and natural gloss of enamel
22	Apply a hardening fluoride varnish to the enamel surface using an applicator	All tooth surfaces are evenly coated with a fluoride varnish
Note. The algorithm shows average values of working time, mixing time and polymerization of self- curing composite materials. In different materials the above-mentioned indicators can differ, therefore before their application it is necessary to		

Algorithm for filling the classes I-V carious cavities in permanent teeth (with unformed and formed roots) with light-curing compos-ite materials

Material supply:

– dental unit;
– dental handpieces (turbine, mechanical);
– cotton rolls;
– saliva ejector;
– kit of dental instruments (probe, mirror, tweezers, excavator, plastic and metal spatula, pluggers, carvers).

– slide paper and glass plates;
– insulating cement (zinc-phosphate, polycarboxylate, glass-ionomer);
– salicylate cement with calcium hydroxide for a medicated cap;
– light-curing composite material, scale of color shades;
– etching gel;
– adhesive systems (of the IV and V generations);
– applicators for adhesive system;
– curing lamp, safety glasses;
– retraction cord;
– transparent light-transmitting matrices, matrix holders;
– light-conducting wedges;
– articulating paper;
– diamond heads, abrasive discs, strips, rubber heads for finishing and polishing of fillings, polishing paste;
– stippling brushes, flosses, paste of average degree of abrasiveness without fluoride, indicators of a dental plaque.

Algorithm to perform dental procedures

N	Action sequence	Criteria for control of correct
1	Carry out a professional cleaning of all surfaces of a tooth which is filled using flosses, stippling brushes and pastes without oil and	Tooth surfaces are not stained by plaque indicators
2	Choose the shade of filling material using the scale in daylight. The surfaces of tooth and scale should be wet	The color of the tooth coincides with the selected scale shade. The test portion of the material applied to [illegible]
3	Isolate of the from saliva with cotton rolls, saliva ejector	The tooth is not in contact with saliva
4	When filling classes II, III, IV and V carious cavities insert a retraction cord into the dental-gingival furrow with a carver	The precervical wall of the carious cavity is separated from a gingival papilla and is fully accessible for visual inspection
5	When filling classes II, III, IV carious cavities insert the transparent light-transmitting matrix into the interdental space and fix it with a matrix holder and light-conducting wedge. One edge of the matrix is located under the gum, and other – at the level of occlusal surface or incisal edge. The matrix must be in close contact with an approximal surface of an adjacent tooth	The matrix in correct position is firmly fixed in the interdental space

6	Carry out an antiseptic treatment of the carious cavity	The carious cavity is clean, does not contain dentin chips
7	Dry out the carious cavity for 10—20 seconds	The carious cavity is dry
8	In the case of acute deep caries in formed permanent tooth and in the cases of acute medium and deep caries in teeth with unformed roots, apply a medicated cap of the salicylate cement with calcium hydroxide to the bottom	The medicated cap is dense, determined only in the projection of pulp horns
9	Before filling of the carious cavity with a light-curing composite material apply an insulating cap of ZP or GIC, or Zn PC cement	The Insulating cap is dense, it evenly covers the bottom and walls of the carious cavity to the enamel-dentin junction
10	Carry out total etching of hard tooth tissues using gel with 37 % orthophosphoric acid. The etching gel should be first applied to enamel, and after 15 seconds – to dentin. Enamel etching time is 30 seconds, dentin etching time – 15 seconds	The etching gel is distributed evenly on the surface of enamel and dentin. Observance of the etching time
11	Rinse the carious cavity with water for 60 seconds to remove etching gel	The carious cavity does not contain residues of etching gel
12	Replace cotton rolls with dry ones	The tooth is not in contact with saliva
13	Dry out the carious cavity The air jet should be directed obliquely at enamel to avoid overdrying of dentin	The carious cavity is dry. The surface of properly etched enamel has acquired a chalky matte appearance. Dentin should remain slightly moistened
14	Consistently apply the first and the second portions of primer with a slight excess to the surface of dentin and rub it with an applicator for 15-30 seconds to penetrate deep into the tissues. Treat the primer with a weak stream of air to evaporate the solvent for a few seconds. Polymerization of primer is carried out only if it is required by the	
15	Apply the adhesive with an applicator to the surface of enamel, dentin and insulating cap. Evenly distribute it with a weak air jet for 10—20 s. Polymerize the adhesive for 20—30 s. In case of a small size of the carious cavity, the one-component adhesive systems of the V generation can be used. In such cases the application of adhesive is carried out twice	Compliance with time of treatment and polymerization of adhesive. The surface of enamel and dentin is shiny, evenly covered with a thin layer of the adhesive

16	Placement of the composite material into the carious cavity in portions with a carver. The thickness of each layer should not exceed 2 mm. Carefully condense each, especially the first, portion of material with a plugger. Polymerization of each portion should be carried out for 20—40 seconds. It is necessary to start polymerization from the wall side of the carious cavity to which this portion of material should be attached. When the last layer is	The composite material fills entire cavity with a slight excess and fits tightly to the edges of enamel
17	Implement postbonding to eliminate microcracks. Treat surface of the filling and enamel with an adhesive and polymerize it for 20—30	The surface of the filling and enamel is shiny, evenly covered with a thin layer of an
18	Check occlusion with an articulating paper. Perform a grinding of filling with diamond or carborundum heads, flexible abrasive discs and strips	The filling does not violate occlusal contacts (there are uniform point contacts on filled and adjacent teeth). The filling reproduces the anatomical shape of tooth, fits tightly to the edges of enamel. When filling the carious cavities of II, III and IV classes, contact point is dense: a dental floss stays only in contact zone and moves freely in an interdental
19	Perform final polishing of the filling with diamond heads, flexible abrasive discs, rubber heads with fine abrasive paste	The filling has a smooth surface and a natural gloss
20	Carry out the final light polymerization. Each surface of the filling is polymerized for 10-20 seconds. The light guide is placed perpendicularly, as close as possible to the surface of filling	
Note. The algorithm shows the average time of treatment and polymerization of an adhesive systems, as well as polymerization of composite materials of light hardening. In different materials the above- mentioned indicators can differ,		

Test tasks to the section "Filling of the carious cavities in temporary and permanent teeth"

1. In a 6 years old child the dentist treats caries of the first temporary molar. How should glass-ionomer cement be insertsd into prepared carious cavity during filling?

A. In one portion B. In several portions C. In layers

2. During preventive examination a 12-year-old child fissure caries in the 16th tooth was diagnosed. A dentist used the silver amalgam for filling. In what terms should be grinding and polishing of permanent filling with amalgam carried out?

A. Immediately after filling
B. In 5 min after filling
C. In 10 min after filling
D. In 12 hours after filling
E. In 24 hours after filling

3. Parents of a 5-year-old child complain about the destruction of his lateral teeth of the lower jaw. On the occlusal surfaces of 74 and 75 teeth, carious cavities within the cover dentin were found. What dental cement is advisable to use for permanent filling of temporary teeth in this case?

A. Zinc-phosphate
B. Glass-ionomer
C. Polycarboxylate
D. Ca-containing
E. Zinc-eugenol

4. During preventive examination of 11 years child the small carious cavity was found within cover dentin in a dental pit of the 36 tooth. What dental material is advisable to use for permanent filling in this case?

A. Ca-containing cement
B. ZOE-containing cement
C. Glass-ionomer cement
D. Zinc-phosphate cement
E. Polycarboxylate cement

5. In a 10-year-old child the class III carious cavities were found in the 11 and 21 teeth. To restore their anatomical shape, a dentist chose the light-curing composite material. What acid and in what concentration is used for enamel etching for adhesive filling technique?

A. 37% orthophosphoric acid solution
B. 0.1 % orthophosphoric acid solution
C. 5 % polycarboxylic acid solution
D. 1 % polycarboxylic acid solution
E. 7% orthophosphoric acid solution

6. A dentist chose the light-curing composite material for permanent filling of the class II carious cavity in the 14h tooth of 12 years old child. What means should be used to restore contact point in this case?

A. Distal carver.
B. Crescent-shaped carver
C. Metal matrix and wooden wedges
D. Transparent matrix, light conductive wedges

7. A dentist chose a light-curing composite material for permanent filling of class II carious cavity according to Black in 25th tooth of a child of 13 years. What should be optimal thickness of each layer of material, consistently introduced into

carious cavity when filling?

A. 0.5–1 mm B. 1.5–2 mm C. 3–4 mm D. 4–5 mm

8. In a 5-year-old child the carious cavities on contact surfaces of the 54 and 55 teeth were found. A dentist chose the compomer for their permanent filling. What is the method of placement of this material into carious cavity?

A. In one portion B. In two portions C. Layer-by-layer

9. In a 15-year-old teenager the carious cavities on medial contact surfaces of the 11 and 21 teeth

were found. Cavities are located below the level of gingival margin. A dentist chose the light-curing composite material for their permanent filling. What matrix should be applied in this case?

A. Metal with a ledge
B. Metal without a ledge
C. Plastic with a ledge
D. Plastic without a ledge

10. In a 14-year-old child on the medial contact surface of the 22 tooth, a dentist found the class IV carious cavity. What filling material is the most optimal for permanent filling in this case?

A. Glass-ionomer cement
B. Ca-containing cement
C. Light-curing composite
D. Self-curing composite

Correct answers to the test tasks to the section Filling of carious cavities in temporary and permanent teeth

1 — A
2 — E
3 — B
4 — C
5 — A
6 — D
7 — B
8 — B
9 — C
10 — C

Chapter 7

PREPARATION OF CARIOUS CAVITIES IN PRIMARY AND PERMANENT TEETH

Dental caries is a pathological process that occurs after the eruption of a tooth and is characterized by progressive demineralization of hard tissues with the gradual formation of defect in the form of a carious cavity. In the case of carious cavity, the main method of treatment is preparation and filling of the tooth with resto- ration of its anatomical shape, as well as functional and aesthetic characteristics.

Classification of carious cavities

At the end of the XIX century, Black G. V. offered the classification of cari- ous cavities, based on their localization and features of preparation. According to this classification, all carious cavities are divided into 5 classes depending on the group of teeth and affected surface of the crown (Fig. 7.1):

Class I – carious cavities located in pits and fissures on the occlusal surface of molars and premolars, the palatal surface of upper incisors, and in the buccal and oral (palatal) pits of molars.

Class II – carious cavities located on contact (proximal) surfaces of molars and premolars.

Class III – carious cavities located on contact (proximal) surfaces of incisors and canines without involvement of the incisal edge and angle of the crown.

Class IV – carious cavities located on contact (proximal) surfaces of incisors and canines with involvement of the incisal edge and angle of the crown.

Class V – carious cavities located in the cervical area of all groups of teeth.

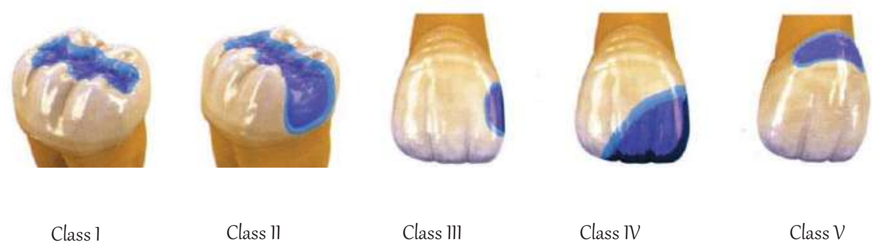


Fig. 7.1. *Schematic representation of carious cavities of different classes according to Black G.V. classification*

Main stages of carious cavity preparation

Preparation of carious cavity – is the operative method of dental caries treatment. The main purposes of tooth preparation – removing the carious tissues and formation of carious cavity for future filling, preservation of the strength characteristics of tooth (resistance), as well as a reliable retention, aesthetics and medical efficacy of the restoration (Fig. 7.2).

Preparation of carious cavity is the most important stage of caries treatment and largely affects its result. During preparation, it is reasonable to follow several rules given below.

1. Medical validity of provided manipulations and gentle attitude to the hard tissues of teeth are extremely important in the treatment of teeth in children.
2. Painlessness of all medical, diagnostic and preventive manipulations is necessary, that is especially important when working with children.

Rules for painless preparation of the carious cavity:

- use sharp burs and serviceable (without vibration) handpieces;
- bur's movements should be intermittent, in the form of commas (as if we are putting a comma);
- use air-water cooling handpieces;
- use high-speed handpieces;
- it is necessary to be especially careful when working on sensitive areas of tooth: in the area of dentin-enamel junction and the area of peripulp dentin;
- perform psychological or / and medical preparation of the child.

3. Rationality and technological effectiveness of medical manipulations. This rule assumes the choice of effective and most rational methods, instruments and techniques of preparation of carious cavity. Doctor should see the area of his work well and how he performs it, be aware of the ultimate goal of his actions.

a *b* *c*

Fig. 7.2. Preparation of class I carious cavity according to Black G.V.: *a* – carious cavity on the occlusal surface; *b* – preparation of the carious cavity; *c* – variant of formation of the I class arious cavity

4. Creation of optimal conditions for long-term service of the filling and the functionality of tooth:
– resistant form of carious cavity will ensure the stability of tooth tissue to mechanical stress and the action of cariogenic factors;
– retention form of carious cavity will provide a strong and reliable mechanical fixation of the filling;
– design of carious cavity according to the physical and mechanical properties of filling materials and ergonomic characteristics of tooth tissues.

Design of tooth preparation takes into account the stage of tooth root development (morphological features of enamel and dentin, topographic features of pulp chamber), depth of the lesion, and the nature of filling material that will be used to restore a defect.

Polymer restorative materials (composites, compomers) allow maximum conservation of tooth hard tissue and therefore are considered to be "minimally invasive" by design. When using polymer restorative materials and glass-ionomer cements, carious cavity is formed following the "principle of adhesive preparation". It should be round or pear-shaped, with smooth contours, smooth transitions between the bottom and walls. The edges of enamel are smoothed (enamel margins of some composite restorations may utilize a beveled so as to increase the retention form of preparation by increasing the area of enamel available for bonding).

If the filling is performed with materials that do not have adhesive properties (amalgam), the formed carious cavity should have a box-like shape, with a flat bottom, right angles between walls and bottom of carious cavity. The design of retention form is related to retention needs of the anticipated restorative material. Amalgam restoration requires the special formation of convergent tooth walls: oral and vestibular walls must converge occlusally, approximal walls – diverge.

The steps of carious cavity preparation were established by Black G.V. and includes five consecutive stages: I – opening;

II – widening;

III – necrectomy;

IV – formation;

V – beveled enamel margins.

Opening of carious cavity consists of removing the overhanging enamel edges to create convenient access for examination and preparation of carious dentin. To perform this manipulation, a water-cooled turbine handpiece and diamond heads of fissured or spherical shape should be used. When working with a fissure bur, its lateral faces cut out the edges of enamel, closing the entrance to carious cavity. The spherical bur is inserted into carious cavity and the overhanging enamel is removed with intermittent movements (from the bottom of cavity to outside).

Widening of carious cavity is carried out up to healthy, not affected hard tissues of a tooth. With the widening of carious cavity, it is necessary to remove the fissures affected by caries; align the enamel edge; round off the sharp angles along perimeter of carious cavity. The external outlines of prepared carious cavity are created. The stage of widening of carious cavity, as a rule, is combined with the stage of its opening. It is performed with fissure burs or diamond fissure hand- pieces. Purpose of this stage is to prevent the development of secondary (recur- rent) caries.

Necrectomy involves the removal of carious affected dentine (softened or pigmented) from the walls and bottom of carious cavity. Volume of necrectomy is determined by the clinical course of caries, localization and depth of carious cavity. Necrectomy is performed by sharp excavators of different sizes and spherical (carbide) burs.

If there is softened dentin on the bottom and walls of carious cavity (acute course of dental caries), necrectomy is started with a sharp excavator, chosen according to the size of carious cavity. The movements of excavator are directed from bottom to walls of carious cavity. Necrectomy in case of acute caries is com- pleted with burs of different shapes (mainly spherical of the appropriate size) us- ing a mechanical handpiece at low speed of rotation to prevent accidental opening of the pulp horn.

In case of chronic course of dental caries, only a mechanical handpiece and burs are used to remove dense pigmented dentin from the walls and bottom of carious cavity. The convenient burs for necrectomy are carbide burs (spherical, cylindrical or cone-shaped), with good cutting properties. Removal of carious dentin is carried out by intermittent comma-shaped movements of a bur, avoiding constant contact of a bur with hard tissues of tooth. To determine the quality of necrectomy, it is advisable to use caries markers – special dyes to paint infected dentin.

Formation of carious cavity – is creating a shape that ensures reliable fixation of the filling material (retention) and the stability of filled tooth to functional load (resistance). At this stage of the preparation of carious cavity, it acquires the final external and internal contours. To form carious cavity, both turbine and angular (mechanical) handpieces with burs of different shapes (inverted conical, conical and fissured) are used. The extent of carious cavity formation is determined by the type of filling material that will be used for filling. The careful formation is required for further filling with amalgam, since amalgam has no adhesion to the hard tissues of tooth, and is retained in the carious cavity only due to mechanical retention. Before filling the carious cavity with composite materials, compomers or glass-ionomer cements (this materials have distinct adhesive properties to the hard tissues of tooth) the stage of formation of carious cavity is not performed.

When applying adhesive filling techniques (composite materials, compomers) the stage of carious cavity formation in frontal teeth provides for the creation of enamel bevel. The enamel bevel is necessary to increase the contact area of filling material with enamel, which increases the retention of filling in carious cavity, as well as to smooth out the edge of filling, which improves the aesthetic of resto- ration. The enamel bevel is formed at an angle from 10 ^{o} to 45 ^{o} to the enamel sur- face. It can capture the entire layer or only part of it. The width of enamel bevel is 1.5−2.0 mm. The enamel bevel is formed by conical or flame-shaped burs, turbine handpiece with air-water cooling.

Finishing of the cavity enamel edges is the final stage of carious cavity for- mation. After preparation of walls of carious cavity, the bundles of enamel prisms with radial direction are dissected. As a result, cracks and slits are formed, the connection with the underlying dentin is lost. The areas of enamel with such de- fects under action of chewing load, as a result, can be destroyed. This leads to a violation of the marginal discrepancy of filling material, the development of secondary caries and loss of fillings. Therefore, it is recommended to perform finishing treatment of the enamel edge to remove damaged areas of enamel and improve the contact of hard tooth tissues with filling materials. Finishing of the enamel edge is carried out using 16-or 32-sided carbide burnishers or fine-grained diamond heads (red or yellow mark) of the appropriate size, cylindrical or con- ical shape, as well as with the help of grinding discs. It is recommended to work with finishing burs at a low speed (mechanical handpiece) without pressure, with mandatory air-water cooling.

Principles of carious cavity preparation

The choice of tactics of carious cavity preparation in primary or permanent teeth in child depends on the stage of tooth development, depth, and localization of carious cavity, as well as on the material that will be used for filling (amalgam, composite materials, cement).

For the first time the tactics of preparation of carious cavities considering the properties of filling materials, aimed at reducing the risk of recurrent caries, was developed by the American dentist Black G. V. at the end of the XIX century. Ac- cording to the concept of Black, convex and smooth surfaces of the tooth (cusps, equator, crown rounding) are well cleaned, cariogenic microorganisms are not fixed on them and therefore caries does not develop. He called these areas "im- mune zones of the tooth". Along with this, there are areas on the crown of tooth where favorable conditions are created for fixing the cariogenic microflora. These are fissures, proximal surfaces, precervical area of the tooth. Black called these areas “caries-reactive (caries-susceptible) zones” and proposed to remove them during the preparation of carious cavity. All, even small, carious cavities are artificially expanded to the caries-immune surfaces of the crown. Formation of a sufficiently large box-shaped carious cavity was important stage of cavity prepa- ration.

The positive aspects of this method of preparation are: low frequency of recurrent caries, durability of fillings and the possibility of applying unified approaches to preparation. The disadvantages: in the process of preparation a large amount of healthy tooth tissues is removed, the mechanical strength of the crown part of tooth decreases, preparation requires more time and efforts of a doctor.

Principles by Black G.V. preparation (“preventive expansion”):

– the cavity outline should include not only carious lesion but and contiguous pits and fissure;
– cavity margins should be placed where they are accessible to routines brushing and least exposed to occlusal forces;
– establish resistance and retention form of cavity.

Today, the principle of “preventive expansion” is used less often, only when us- ing amalgam, metal and ceramic inlays (materials with low adhesive properties). For adhesive restorations, the technique of minimally invasive preparation is used. Principles of preparation: gain accesses to carious cavity, removal of caries and formation of cavity outline (should be limited to the carious lesions and any adjacent decalcified areas). The aim is to preserve the healthy structure of tooth as much as possible (Fig. 7.3).

The principle of preventive filling was developed in the late XX century after the appearance of dental filling materials with high adhesive properties: compos- ite materials, compomers, glass-ionomer cements. It is based on the technique of minimally invasive preparation and provides for minimal removal of healthy tooth tissue during preparation of carious cavity and sealing of fissures (invasive

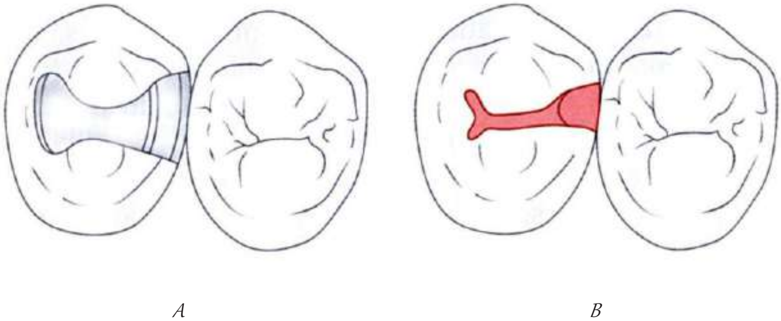


Fig. 7.3. *A – Box shaped tooth preparation for amalgam; B – Conservative tooth preparation for composite*

or non-invasive). When using the method of preventive filling, it possible to make the filling of cavities of irregular shape, small depth, with a rounded bottom.

The method of preventive filling is widely used in practice of children's thera- peutic dentistry in the treatment of caries of permanent teeth, because it is mini- mally invasive, low-traumatic, does not require much time and effort, has a strong preventive orientation.

Modern methods of preparation of children's hard tooth tissues

Known today methods of preparation of hard tooth tissues are divided into contact and non-contact. Contact methods include mechanical, chemical-mechanical or ultrasonic treatment of the carious cavity. Non-contact methods include air-abrasive and laser preparation of hard tooth tissues.

CONTACT METHODS OF PREPARATION OF HARD TOOTH TISSUES

Mechanical method of preparation is the preparation of carious tissue using dental handpieces, burs and hand tools. Today this method of preparation of hard tooth tissues in the treatment of dental caries is the main one.

When preparing children's hard tooth tissues by mechanical means, it is advisable to apply the technique of minimally invasive preparation, especially in the treatment of fissured caries (class I according to Black) with small carious defects, which are quite common for children (Fig. 7.4). The main features of minimally invasive preparation are:

– *focus only on the defect*. Preparation is carried out with spherical burs or diamond heads only within carious hard tissues. The rounded shape of cavity guarantees the stability of dental tissues and fillings to stressful chewing loads;
– *possibility of preservation of the prepared enamel* without support on un- derlying dentin. If you replace carious dentin with a composite, which is an elastic material, it will take on the function of supporting and amortiza-

a

b

Fig. 7.4. Minimally invasive preparation of carious cavities of class I according to Black: *a* – carious cavities of class I according to Black; *b* – variant of minimally invasive preparation of carious cavities of class I according to Black

tion of the enamel. Thus, the larger amount of outer enamel is possible to save, better will be the tightness of a filling and the forecast concerning its durability;

– the use of modern adhesive systems that can provide reliable retention of filling material (*"less preparation, more infiltration"*).

Technique of minimally invasive preparation involves the use of special burs for preparation, as well as the mandatory use of adhesive filling tech- nique. Features of the working part of burs for minimally in- vasive preparation are the var- ious form of the working part repeating anatomical features of a structure of fissures, the smaller size for careful preparation (sets "Komet" (Germany), "Diatech" (Swiss), "Fissurotomy") (Fig. 7.5).

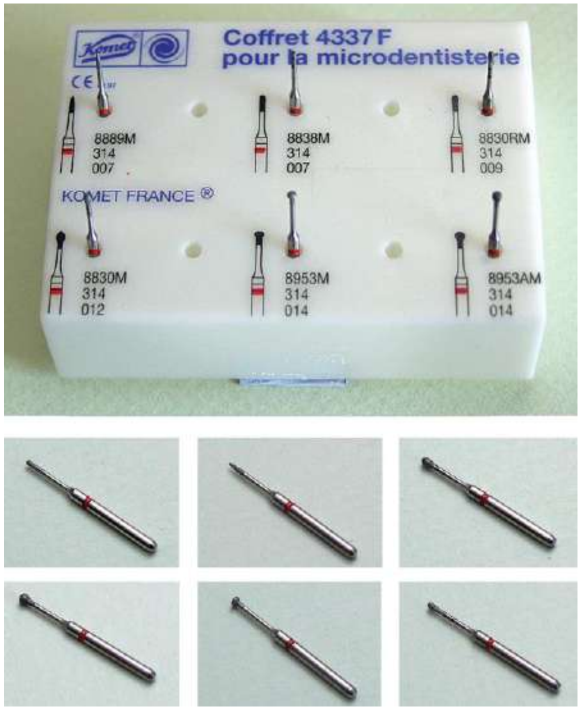


Fig. 7.5. Set of instruments for minimally invasive preparation of carious cavities

A variation of the method of mechanical removal of affected hard tooth tissues, which today is widely used in pediatric therapeutic dentistry for treatment of dental caries in primary teeth, is the method of mechanical preparation without using handpieces and burs, which is called ART-technique (Atraumatic restorative treatment). The technique was developed by professor Taco Pilot (Netherlands).

Indications for use of the technique of atraumatic restorative treatment are: need for preparation of teeth despite the stage of formation in case of a low level of cooperation between a child and a doctor; preparation of teeth for children with increased nervous excitability; work in the absence of proper dental equipment.

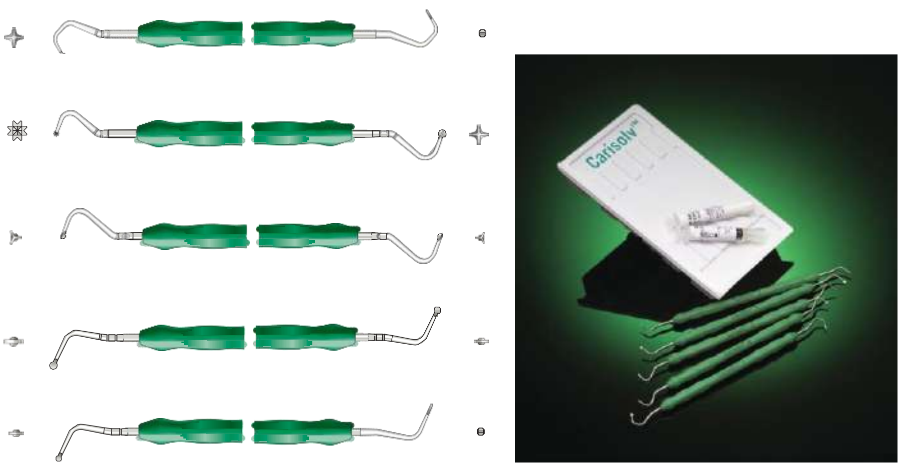
The technique of preparation is to remove the caries-affected tissue of tooth by hand with the help of sharp excavators of different sizes and enamel knives (Fig. 7.6) with a mandatory subsequent filling with the glass-ionomer cement (material with strong caries preventive properties). The set of necessary tools includes: dental mirror, probe, forceps, enamel knife (to remove overhanging edges of enamel), excavators of various sizes, plugger-carver.

Fig. 7.6. *Enamel knife*

Chemical-mechanical method of preparation involves the use of chemical preparations capable of destroying the tissues affected by carious process, which are then removed with hand tools.

The system of chemical-mechanical preparation "Carisolv" (Sweden) consists of two gels and a set of special hand tools (Fig. 7.7). One gel contains three amino acids (leucine, lysine, glutamic acid), the other – antiseptic (sodium hypochlorite of low concentration (0.5 %)). Both gels are mixed before use.

For mechanical removal of tissues affected by caries, they are first treated with gel. Then a set of atraumatic tools, having a different geometric shape of the work- ing part and a different number of cutting faces, which quickly remove carious dentin, saving the healthy one, is applied. Instruments are selected according to the size, location of carious cavity and the possibility of access to it.



a *b*

Fig. 7.7. *Set "Carisolv" for chemical-mechanical preparation of carious cavities: schematic representation of the working parts of*

various tools (*a*), appearance of the set (*b*)

Technique of chemical-mechanical preparation: a gel is applied into carious cavity; a chemical reaction occurs (softening of carious dentin) within 30 seconds. Then all affected dentin is carefully removed with circular and scraping movements of the tools. Gel is applied into carious cavity several times, until its color (pink) ceases to change color (into transparent). Carious cavity after preparation is filled with glass-ionomer cement.

The method of chemical-mechanical preparation is an alternative to the method of traditional preparation and is used in pediatric therapeutic dentistry due to the ability to remove carious dentin without use of a drill machine. This method of preparation is advisable to apply for children with labile psyche, as well as at low level of cooperation of a child with a doctor to avoid negative attitude to dental treatment in the future.

NON-CONTACT METHODS OF PREPARATION OF HARD TOOTH TISSUES

Acoustic method of preparation involves use of the sound and ultrasonic handpieces and special nozzles to them with a diamond cover of the working part (Fig. 7.8). The nozzles of working part have a diverse shape: cone-shaped, spherical (for classes I, III, IV, V carious cavities), hemispherical, shovel-shaped (for class II). In the process, the tip of nozzle carries out microscopic vibrating movements, while removing the hard tooth tissues affected by carious process, and the walls of carious cavity are temporarily treated.

Pneumokinetic (air-abrasive) method of preparation – is the non-contact method of preparation of carious cavity, is a kind of surface sandblasting the method.

The technique of pneumokinetic air-abrasive preparation consists of the impact of focused flow of abrasive (for example, aluminum oxide powder or sodium bicarbonate with particle sizes of 25–50–100 microns) on the hard tooth tissues. Principle of operation of the devices designed for air-abrasive preparation (AirFlow Prep K1, EMS, Futura) is a directed supply of aerosol jet containing water and abrasive through the special handpiece (Fig. 7.9, *a*). The jet selectively removes carious tissue. Depth of preparation can be adjusted by changing the water supply to handpiece.

Fig. 7.8. *Devices for ultrasonic preparation*

Both a doctor and a patient should use vacuum evacuator and glasses in the process of work. It is recommended to apply cofferdam beforehand to avoid inhalation of aerosol by patient and damage of mucous membrane by abrasive jet. The air-abrasive method of preparation is used for preparation of small carious cavities. Rough surface without car- ious lesions with maximum contact area is formed under the influence of an abrasive jet.

a

b

Fig. 7.9. Equipment for abrasive preparation of carious cavity: *a* – a handpiece; *b* – the apparatus "AirFlow" of company "EMS"

Laser method of preparation is contact-free method of preparation of hard tooth tissues, carried out with the help of special laser apparatus. The apparatus consists of three main parts (Fig. 7.10): basic unit that generates light of certain power and frequency, light guide and laser handpiece, with which a dentist works directly in the oral cavity. The handpieces are equipped with water-to-air cooling system for con- stant temperature control and removal of prepared fragments.

Fig. 7.10. Apparatus for laser preparation of hard tooth tissues

The preparation is as follows: every second, the base unit generates about ten rays, each of which carries a certain "portion" of energy. The laser ray, falling on the hard tooth tissues, heats the water contained in it. Water increases in volume, causing micro-cracks in enamel and dentin. Tissues located close to the zone of action of water vapor are heated by no more than 2 °C, since the laser energy is prac- tically not absorbed by hydroxyapatite. Enamel and dentin particles are immediately removed from oral cavity with the help of water-air spray. During laser preparation, both a doctor and a patient need to wear safety glasses.

Advantages of the laser preparation:

– it is not accompanied by strong heating of the hard tooth tissues and does not irritate nerve endings of the pulp, so the preparation process is painless and there is no need for anesthesia;
– preparation is fast enough. At the same time, a doctor can control the process of preparation, and if necessary, immediately stop it with one movement;

- edges of the walls of carious cavity become rounded after preparation and there is no need for additional finishing of the enamel edges. In addition, "lubricated layer" is not formed after laser preparation on the bottom and walls of carious cavity, the surface becomes clean;
- there is no need to treat a carious cavity with antiseptics, since any pathogenic microflora dies under the laser action;
- the laser preparation procedure is non-contact, since none of the components of laser unit comes into direct contact with biological tissues during operation;
- treatment time is reduced because a doctor works with one instrument and does not waste time replacing burs and handpieces, does not process the edges of carious cavity, does not etch the enamel, does not perform anesthesia.

The disadvantage of this method is its limited availability due to the relatively high cost of equipment.

Features of preparation of children's primary and permanent teeth

When preparing carious cavities in children's primary and permanent teeth it is necessary:

a) observe the principles of painless preparation:

- use high-speed handpieces with water cooling;
- prepare without strong pressure to prevent overheating of hard tooth tissues and development of pathological changes in the pulp;
- use carbide burs or diamond heads of small sizes to reduce overheating of hard tooth tissues;
- use qualitative handpieces with minimal vibration and sharp burs;
- carry out the preparation intermittently, it reduces the duration of contact of the bur with hard tooth tissues;

b) take into account anatomical features of the structure of primary and permanent unformed teeth:

- crowns of primary teeth are low and wide; their size is smaller compared to permanent teeth;
- enamel and dentin of primary teeth and immature permanent teeth are less mineralized compared to permanent formed teeth;
- pulp chamber of primary teeth and immature permanent teeth is relatively larger than the one of formed teeth;
- pulp horns of primary teeth and immature permanent teeth are located closer to occlusal surface;

– the thinnest layer of enamel of primary teeth is in the area of precervical and proximal surfaces in comparison with other surfaces of the tooth;

c) give preference to gentle preparation of hard tooth tissues:

– if possible use machineless necrectomy;
– carry out the widening of carious cavity according to the indications (taking into account depth of the process, its localization, the type of filling material and the stage of tooth development);
– carefully treat the edges of carious cavity with diamond fine-grained heads (low mineralization of enamel, the presence of a stage of physiological abra- sion in primary teeth).

Preparation of carious cavities of different classes in primary and permanent teeth

Features of preparation of class I carious cavities in primary teeth and permanent teeth with unformed roots

Peculiarity of the class I carious cavities in children is that the size of carious dentine lesion is always greater than the size of carious enamel lesion. The center of carious lesion resembles a triangle, the top of which is directed to the enamel, and the base – to the pulp. Therefore, carious cavities localized in fissures of oc- cclusal surface have a small inlet, especially in case of acute caries (Fig. 7.11, *a*). Preparation of class I carious cavity begins with its opening − removal of over- hanging edges of enamel. This manipulation is performed by turbine handpieces with cylindrical, spherical diamond heads or carbide burs, the diameter of which is slightly smaller than the diameter of inlet to carious cavity.

The volume of widening of class I carious cavity depends on the chosen principle of preparation.

For small to moderate direct composite Class I restorations, minimally invasive tooth preparation can be used. It does not require the typical characteristics of resistance and retention form of carious cavity after preparation.

All areas susceptible to caries are removed if the preparation is carried out according to the Black G.V. principle. When preparing fissures, slopes of the cusps of occlusal surface are preserved as much as possible.

Applying the principle of “preventive filling”, carry out fissurotomy – cutting fissures within the enamel, if there is a suspicion of their damage by caries. It is advisable to use burs of the special shape − fissurotomes. When preparing fissures with such burs, a cavity is formed with walls diverging towards the occlusal sur- face, which additionally ensures easy application of adhesive system and filling material.

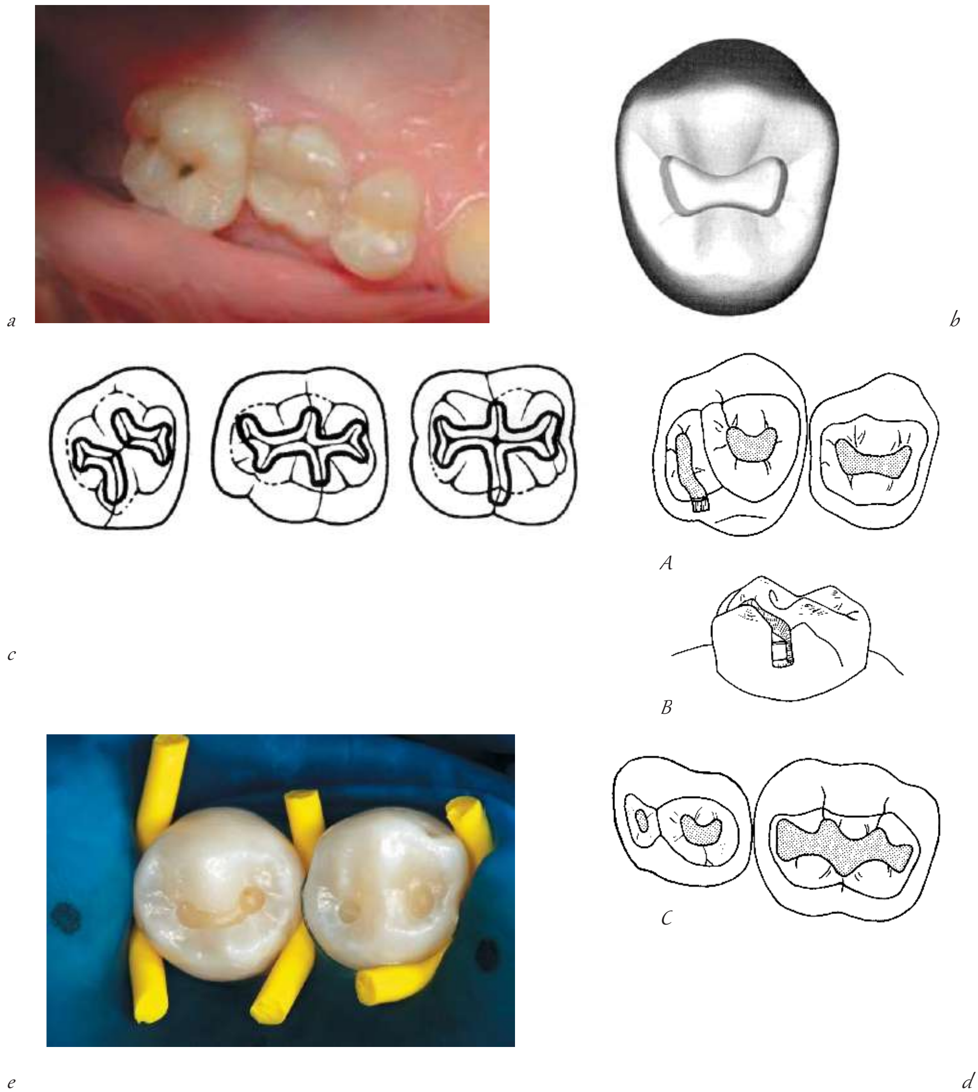


Fig. 7.11. *Preparation of class I carious cavities: a – class I carious cavity in permanent molar; b – variant of preparation of class I carious cavity in premolar; c –ways of forming of class I carious cavities ; d – variants of forming of class I carious cavities in primary teeth (A – upper jaw; B – with inclination to the palatal surface; C – lower jaw); e – variants of forming of class I carious cavities in premolars*

Stage of necrectomy involves the removal of all carious dentin (softened or pigmented) from the walls and bottom of carious cavity. In the case of deep caries, preparation of the bottom of carious cavity is carried out carefully with spherical burs of medium or large size with mechanical handpiece; the speed of bur should be low. In this case, the bottom of carious cavity may have a free shape.

When preparing class I carious cavities in primary and permanent teeth of children, it should be remembered that the horns of pulp are marked much closer to the oc- clusal surface compared to permanent teeth of adults. Special attention should be paid to the carious cavities located in dental pits on the palatal surface of upper incisors, since the horns of pulp is almost close to surface here. Therefore, preparation of the bottom of such carious cavity should be carried out carefully, especially in the areas of projection of pulp horns, in order to avoid accidental opening.

Formation of class I carious cavity in both primary and permanent teeth is determined by the anatomical features of occlusal surface, as well as type of filling material with which this cavity will be filled (Fig. 7.11, *b*). The anatomical struc- ture of occlusal surfaces of primary molars of upper and lower jaws determines the shape of class I cavity. In presence of fissured caries in the IV tooth of upper jaw (54, 64 teeth) and in the V tooth of lower jaw (75, 85 teeth), it is advisable to form one cavity within all fissures of the occlusal surface. When preparing car- ious cavity of the V tooth of upper jaw (55, 65 teeth) and the IV tooth of lower jaw (74, 84 teeth), it is desirable not to connect distal and mesial fissures into one cavity (Fig. 7.11, *d*). This is due to anatomical features of the structure of occlusal surface of these teeth (the distinct enamel ridge between fissures). When prepar- ing distal fissure in the V tooth of upper jaw (55, 65 teeth) it is advisable to incline it to the palatal surface, where there is anatomical recession. In case of carious lesions of the enamel ridge on occlusal surface, both fissures should be combined into one cavity.

When preparing (according to the Black's principle) class I carious cavities, all hard tooth tissues affected by caries should be removed, as well as fissures and other retention zones, unaffected by caries. The ideal depth of cavity should be 0.5 mm below an enamel-dentin junction (about 1.5 mm from the enamel surface). To avoid tension and static deformation of filling material, the outer edges of cav- ity should be smooth, and internal angles – slightly rounded (Fig. 7.11, *d*).

If pits and buccal surface of the second primary molar are affected, carious cavity is formed in the form of a drop or an egg, and all adjacent caries-sensitive fissures and pits are connected.

Small in size cavities in the upper permanent molars (17, 16, 26, 27 teeth) with unformed root, it is desirable to prepare separately, saving the enamel roller sep- arating medial and distal fissures. In the lower permanent molars (37, 36, 46, 47), on contrary, all affected areas of fissures are combined into one cavity. In presence of small size carious cavities on the vestibular surface of permanent molars, they are prepared within the affected area, without output to occlusal surface.

The type of selected filling material determines the formation of carious cavity. If a composite material is used as filling material, class I carious cavity is formed following the principles of "adhesive preparation", namely: the internal contours of cavity should be rounded or pear-shaped; areas of enamel on occlusal surface that do not have support on underlying dentin can be left; the edges of filling should not fall into the zone of occlusal contact with an antagonist tooth (Fig. 7.11, *e*). Therefore, even before preparation the occlusive contacts should be determined with copy paper and form the outer contours of filling so that the occlusive contact would be either within enamel, or within filling material.

If silver amalgam (materials with low adhesive properties) is used as filling material, the stage of formation of class I carious cavity should be carried out very carefully, since it directly affects the fixation of filling in carious cavity. When forming carious cavities in both primary and permanent teeth for amalgam fill- ings, special attention should be paid to the ratio of bottom and walls of carious cavity. The bottom of cavity should be flat, and the walls – sheer. Mesial and distal walls of class I carious cavity should form the angle of $95-100^0$ with bottom. The angles between bottom, buccal and lingual walls of carious cavity should be sharp
– $80–85^0$. The carious cavity should repeat the shape of fissures and be of sufficient depth to ensure the stability (retention) of filling. The edge of enamel should be cut at the angle of $40-45^0$ to surface of enamel.

Features of preparation of class II carious cavities in primary teeth and permanent teeth with unformed root

Class II carious cavities may be located on medial or distal contact surface of molars and premolars (Fig. 7.12, *a*). In addition, there can be a simultaneous caries lesion of both proximal surfaces in one tooth. Class II carious cavities in children are localized more often in the area of contact point (at the level of tooth equator). The lesion of contact surfaces of an adjacent teeth happens often.

Opening of class II carious cavity can be carried out with different accesses. The most common is occlusal access, in which opening of carious cavity is carried out through the occlusal surface of tooth with removal of healthy enamel and dentin located above the center of carious lesions. Use spherical or cylindrical diamond heads, carbide burs and turbine handpiece with air-water cooling. The disadvantage of this access is a significant loss of healthy tooth tissues and de- struction of the marginal ridge on occlusal surface, which is difficult to restore in the process of filling.

In the absence of nearby tooth, direct access can be used to open class II carious cavity. In this case, carious cavity is prepared without output to occlusal surface. Other types of access for the opening of class II carious cavity (vestibular or lingual, gingival and tunnel) are used less often.

Widening of class II carious cavity provides for several approaches according to the selected principle of preparation.

If preparation of carious cavity is carried out according to the Black's principle, all fissures of occlusal surface are removed and the external contours of additional box are created. The sidewalls of class II carious cavity are removed

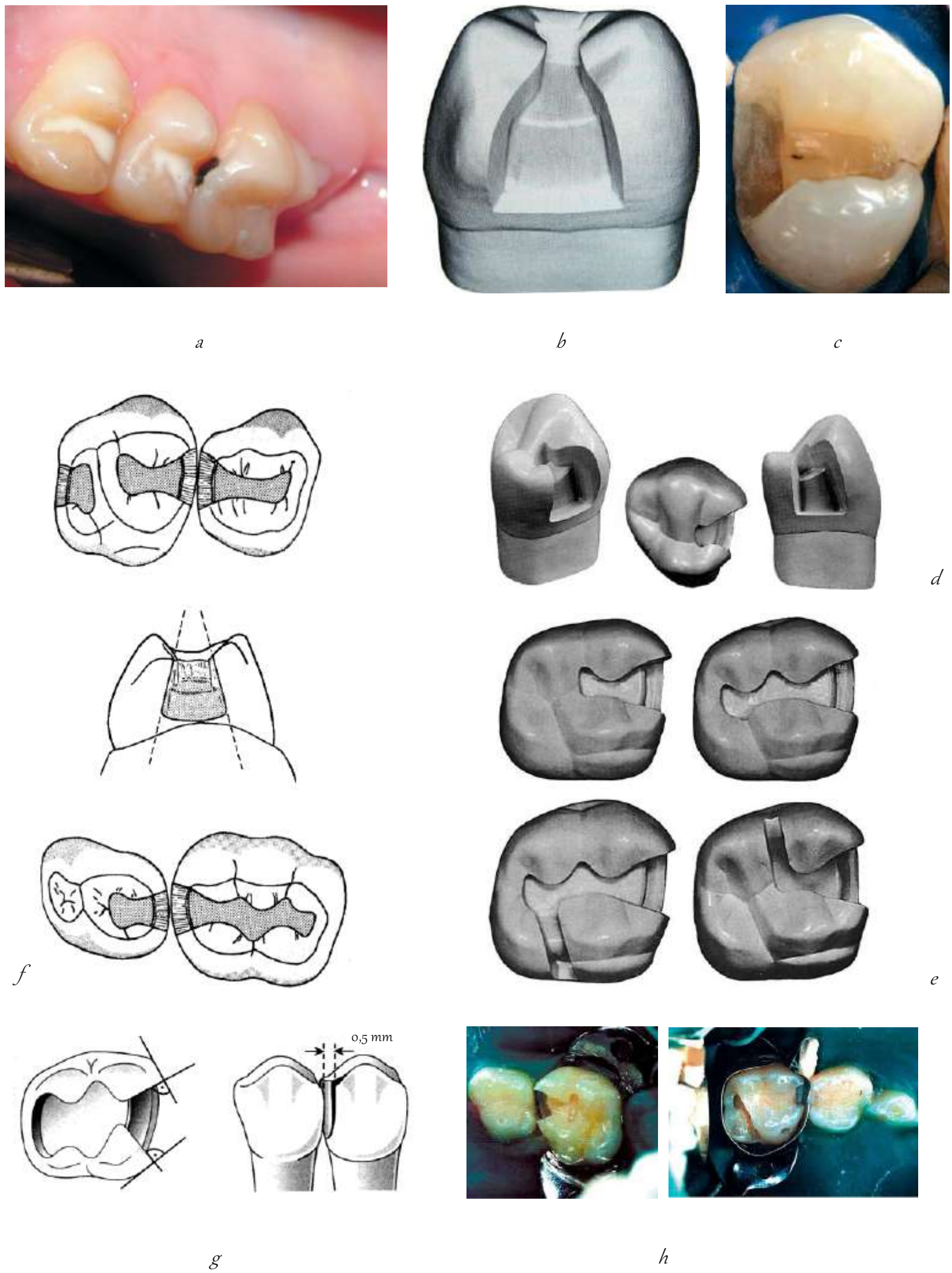


Fig. 7.12. Preparation of class II carious cavities: *a* – class II carious cavity in the first permanent molar; *b* – occlusal convergence of buccal and lingual walls; *c* – prepared class II carious cavity with formation of additional box in premolars; *d* – appearance of prepared class II carious cavity in premolar; *e* – variants of formation of additional box during preparation of class II carious cavities in permanent molars; *f* – variants of formation of

additional boxes during preparation of class II carious cavities in primary teeth; *g* – ratio of the walls of class II carious cavity; *h* – appearance of prepared carious cavity with formation of additional boxes in second primary molars in the buccal and lingual directions to level of well-cleaned surfaces of tooth crown. The sidewalls of carious cavity (especially in cases, where only enamel remains after removal of carious dentin) should not be in contact with adjacent tooth, only the filling material should be in contact with it (Fig. 7.12, *b*).

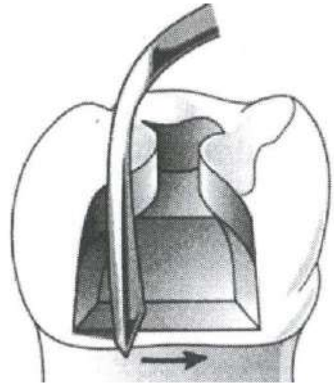


Fig. 7.13. *Necrectomy of pregingival wall with a distal trimmer*

Necrectomy during preparation of class II carious cavities is performed according to general principles. However, special attention should be paid to the pregingival wall. It is the place, where tissues affected by caries can re- main, and will later be the source of secondary caries development. Necrectomy in the area of pregingival wall can be carried out with the help of burs or special tool – the distal trimmer of gingival edge (Fig. 7.13).

Formation of class II carious cavity has certain features since there is the significant chewing pressure on a filling.

Therefore, a secure fixation should be provided for it, maintaining the strength characteristics of tooth crown. Features of formation of class II carious cavity depend on the choice of filling material. If class II carious cavity is filled with com- posite material, its contours are formed smoothed, the angle between pregingival wall and bottom of main cavity is formed right or sharp (90–80°); side walls of cavity are removed from contact with the neighboring tooth, they should diverge slightly towards a neighboring tooth (Fig. 7.12, *c, g)*.

Despite the adhesive properties of modern composite materials, during formation of class II carious cavity, it is advisable to create an additional box on occlusal surface to improve the fixation and uniform distribution of chewing pressure on the filling (Fig. 7.12, *d, e*).

An additional box during the formation of class II carious cavity should have the following parameters:

- depth – 1 mm below an enamel-dentin junction;
- length – twice length of the main cavity, go beyond the middle of occlusal surface;
- width – approximately 1/3 of distance between the tops of chewing cusps;
- the angle between bottom of main cavity and additional box should be 90°, somewhat smoothed (the bottom of class II carious cavity is its vertical wall facing the pulp);
- the shape of additional box should be retentional, most often it repeats the

shape of fissures of occlusal surface, the bottom is flat;

– the walls of additional box should be sheer, mesial (or distal) wall should form the angle of 95–100° with bottom;
– edges of enamel should be cut at angle of 40–45°.

When forming an additional box, excessive removal of hard tooth tissues, especially cusps on occlusal surface, should be avoided. If in the process of prepa- ration most part of chewing cusp was removed, it is necessary to remove it com- pletely, and then to restore with filling material to prevent breakage of cusp under the influence of masticatory pressure. It should be remembered that the edges of filling on occlusal surface should not fall into the zone of occlusal contact (Fig. 7.12, *e*).

If amalgam is used for filling class II carious cavity, the requirements for for- mation of carious cavity are even higher. Main cavity should be box-shaped, pregingival wall should be flat, forming the angle of 80–85° with bottom of main cavity, the side walls should be straight and diverge somewhat towards the contact surface of an adjacent tooth. Be sure to form an additional box on occlusal sur- face with the above mentioned parameters. For more reliable fixation, the angle between bottom, buccal and lingual walls of the additional box should be sharp
– 80–85° (Fig. 7.12, *c*).

In primary teeth, the size and shape of additional box are determined by the anatomical structure of primary molars of upper and lower jaws. An additional box in 54, 64 teeth of upper jaw and 75, 85 teeth of lower jaw is advisable to form within all fissures of occlusal surface. When preparing class II cavities in 55, 65 teeth of upper and 74, 84 teeth of lower jaw, an additional box should be formed at the expense of adjacent fissures (Fig. 7.12, *c*). This requires careful attention to the immune zones (distinct enamel ridge between mesial and distal fissures) (Fig. 7.12, *h*).

In case of extensive carious lesions, when the enamel of prepared cavity re- mains without support of dentin (more often vestibular or lingual wall of main cavity), it must be removed, reducing the height of walls by 2–3 mm, and cover with filling material to avoid breakage.

Use of the technique of preparation of class II carious cavities according to Black is expedient in case of caries lesion of both proximal and occlusal surfaces (so-called medio-occlusal-distal cavities, or MOD).

Features of preparation of class III carious cavities in primary teeth and permanent teeth with unformed root

When preparing and filling class III carious cavities, in addition to restoring the anatomical and functional properties of tooth, a dentist has an important task – to restore or improve the appearance of tooth and its aesthetic characteristics (Fig. 7.14, *a*). In this regard, the approaches to preparation of frontal teeth are somewhat different from the approaches used for preparation of carious cavities in chewing teeth.

When **opening** class III carious cavity, they try not only to create convenient conditions for further preparation, but also to preserve enamel on the vestibular surface as much as possible (especially for permanent teeth). For opening class III carious cavity, direct, oral and vestibular accesses can be used. Direct access is used in the absence of a nearby tooth, as well as in case of gaps between teeth (diastema), which makes such access technically possible (Fig. 7.14, *b*).

Oral access is the most rational from the point of view of aesthetics. So it is most often used in preparation of permanent teeth, using a spherical bur and turbine handpiece, retreating from the contact surface of tooth in about 0.5–1 mm. After trepanation of enamel, it is necessary to expand the entrance hole. It is advisable to protect the adjacent tooth with a metal strip or matrix from accidental damage.

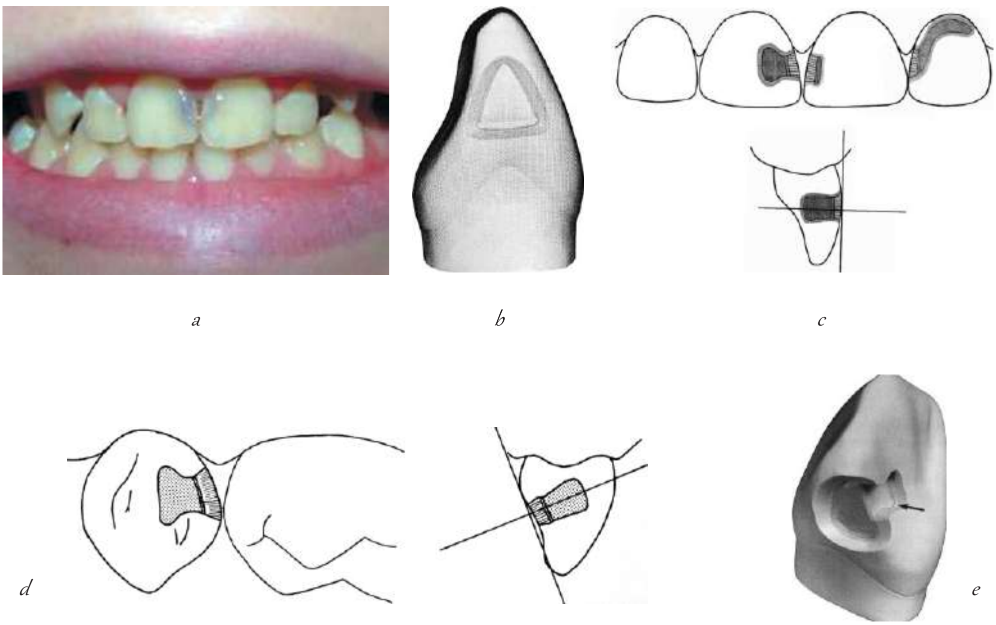


Fig. 7.14. *Preparation of class III carious cavities: a – class III carious cavities in central incisors; b – appearance of prepared class III carious cavities in permanent incisor in absence of neighboring tooth; c – variants for creating the additional boxes of class III carious cavities in primary incisors; d – variants of formation the additional boxes of class III carious cavities in primary canine;*

e – appearance of prepared class III carious cavity in permanent canine with formation of additional box on palatal surface

Vestibular access can be used to open class III carious cavity in primary tooth since it is technically simpler (Fig. 7.14, *c*). Carious cavity is opened through an enamel defect on the vestibular surface of crown. Only damaged demineralized enamel is removed. Externally unchanged enamel, even the one supported by dentin, is maximally preserved. When opening class III carious cavity in perma- nent teeth vestibular access is limited: in the case of crowding of teeth, as well as significant destruction of enamel on the vestibular surface.

Widening of class III carious cavity is performed very carefully since the ex- pansion towards the incisal edge can contribute to its breakage.

Necrectomy involve removal of all demineralized (changed in color) enam- el, as well as all-carious dentin. The contours of carious cavity should be placed within the healthy tissues of tooth, which is due to the need for further aesthetic restoration of tooth.

In case of deep carious cavity, preparation of its bottom (the wall inclined to the pulp) should be carried out carefully to avoid opening the pulp horn.

Class III carious cavity is formed following the principles of "adhesive prepa- ration", since composite materials, compomers, and glass-ionomer cements are widely used for filling carious cavities of this class. The contours of carious cavity should be smoothed, rounded. If dental pit on the palatal surface of incisor is af- fected by caries, it can be combined with main cavity and serve as an additional box for it (Fig. 7.14, *d*). The width of additional box is 1.5−2 mm and the depth
– 1−1. 5 mm (Fig. 6.14, *e*). The mandatory stage of formation of class III carious cavity is formation of the enamel bevel– the width of at least 2 mm, on the front surface of the tooth. It is formed deeper in the pregingival region, using the entire thickness of enamel towards cutting edge, where the depth of bevel decreases.

Finishing an enamel edge is important for the long-term preservation of quality restoration. If this stage of preparation is not performed, a "white line" is formed later on the border of filling material and hard tissues of tooth or edge staining of the restoration as a result of violation of filling tightness. The finishing of the enamel bevel is recommended to be carried out with fine-grained diamond head or 20−32-edged burnishers until a smooth surface is formed. This treatment of enamel edge improves the edge fixation of filling, optimizes the processes of refraction at the border of composite with tooth tissues, which makes it possible to make the "composite/enamel" border invisible.

Features of preparation of class IV carious cavities in primary teeth and permanent teeth with unformed root

Class IV carious cavities differ from class III carious cavities by the lack of crown angle and incisal edge, resulting in greatly reduced strength properties of the tooth (Fig. 7.15, *a*). Class IV carious cavities are formed from class III cari- ous cavities during the progression of carious process or as a result of traumatic fracture of the crown angle, which is quite common in the practice of pediatric dentistry. Preparation of class IV carious cavities is carried out in compliance with the same approaches that are used during preparation of class III carious cavities. The main purpose of preparation is to ensure reliable fixation, strength and optimal aesthetic result of the restoration.

Opening of class IV carious cavities in both primary and permanent teeth is often performed using vestibular access. This is due to the need to create optimal conditions for macro- and micromechanical retention of restoration in the process of preparation. Cavity is opened by diamond spherical heads of small size using turbine handpiece with air-water cooling. Other types of access – direct and oral, are less often used.

Widening of class IV carious cavities is not additionally done.

Necrectomy is performed following the principles of aesthetic restoration of the frontal teeth with composite materials. Be sure to remove all affected pigmented dentin, preparation of the bottom of carious cavity is performed carefully to avoid opening the pulp.

Formation of class IV carious cavities in most cases involves the creation of additional box on the oral surface of tooth in the area of dental pit. The width of additional box is 1.5–2.0 mm, the optimal depth is 1–1.5 mm. Pregingival wall of additional box is formed, retreating 1–1,5 mm from the gingival margin. The an- gle between bottom of the main cavity and the additional box is formed rounded (Fig. 7.15, *b*). The expediency of forming an additional box for preparation of class IV carious cavities, especially in case of significant defects of the crown part of

b

Fig. 7.15. Preparation of class IV carious cavities: *a* – class IV carious cavities in the temporary central and lateral incisors; *b* – variant of additional box formation during class IV carious cavity preparation in the canine

tooth, it is due to the need to ensure reliable retention of restoration. In such cases, retention only due to the adhesion of filling material may be insufficient.

In primary teeth it is advisable to form an additional box on the vestibular surface by combining class IV carious cavity with class V carious cavity, since such combination of carious lesions is quite common in frontal primary teeth.

Mandatory step in formation of class IV carious cavity is the creation of wide enamel bevel on the vestibular surface of tooth to ensure reliable fixation of a composite to enamel. The area of enamel bevel should be twice larger than the area of defect.

Finishing treatment of enamel edge is carried out in the same way as in the preparation of class III carious cavities.

Features of preparation of class V carious cavities in primary and permanent teeth with unformed root

Class V carious cavities are located very close to the gingival margin and sometimes extend under it (Fig. 7.16, *a*). In this regard, when preparing and filling class V carious cavities a dentist has to solve a number of practical problems: additional protection of the gingival margin from mechanical and chemical damage during preparation and filling is required; retraction of gingiva is necessary for a sufficient overview and possible preparation of the pregingival wall of carious cavity, as well as to provide the dryness of carious cavity during its filling. Macromechanical retention of filling material in carious cavity should be considered, since the adhesion of restoration material, especially in the pregingival area, does not provide sufficient retention of the filling.

Opening of carious cavity involves the removal of carious enamel at the edges of carious cavity.

Widening of class V carious cavities is advisable to carry out in case the acute course of dental caries, in patients with multiple lesions of teeth with caries localized in the precervical region. The pregingival wall is expanded to the level of gingiva or by 0.1–0.2 mm under gingival edge (to the level of enamel-cement junction). In the direction of occlusal surface, widening of carious cavity is carried out to the border of middle and precervical third of the vestibular surface – the area that is well cleaned when chewing.

Necrectomy involves removal of all carious tissues using a spherical carbide bur and mechanical handpiece at a low speed under constant visual control of the bottom of carious cavity. Special care should be taken when preparing the pregingival wall to prevent injury to the gingivae, as it will complicate the filling process due to bleeding. To prevent this, it is necessary to use retracting cords

with hemostatic agents, placing them in the dental-gingival furrow before the beginning of preparation.

Formation of class V carious cavities is aimed at giving it a shape that provides macromechanical retention of the filling, especially if the pregingival wall is lo- cated under gingiva.

The optimal form for class V cavity is a kidney-shaped one with pregingival wall located in parallel to the gingival margin. Sometimes, when the size of cavity is small, it is formed in the form of an oval. The bottom of carious cavity is formed convex, taking into account that the depth of 1–1. 5 mm from the enamel surface is considered safe (Fig. 7.16, *b*). To give the cavity greater retention the retention undercuts are formed with the help of wheel-shaped bur in cavity walls. Another option for increasing retention is formation of converging walls of the carious cavity. In this case, diameter of the inlet opening of carious cavity becomes small- er than its bottom.

When filling with composite materials, the edges of carious cavity and enamel bevel are formed. On the pregingival and lateral edges of carious cavity, a small bevel is formed – 0.5–1.0 mm, and towards the equator of tooth – a wide bevel (2–5 mm) to the level of tooth equator .

Finishing treatment of the edges of carious cavity is carried out according to the generally accepted rules for adhesive restorations. Finishing treatment of gin- gival wall is advisable to carry out with the help of distal trimmer to avoid injury to the gingivae.

In the precervical area of primary teeth there is a special anatomical creation – an enamel bulge. It should be remembered that the enamel layer in this area is thinner compared to other areas of the tooth. When opening, it is necessary to be as careful as possible to avoid accidental opening of the pulp. If necessary, the bottom of cavity can be left convex.

a

b

Fig. 7.16. *Preparation of class V carious cavities: a – class V carious cavities in primary lateral incisor and canines; b – variant of formation of class V carious cavity in permanent incisor*

Choice of tactics for the preparation of hard tissues in primary and permanent teeth depending on the period of tooth formation

At the stage of roots formation of primary teeth, the tooth cavity is large relative to volume of the crown, the horns of pulp are closer to occlusal surface that changes the topographic ratio of dentin and tooth cavity, fissures are less mineralized. Gentle preparation, especially towards the pulp of tooth, in order to critically evaluate the depth of lesion, it is advisable to carry out at this stage of development of primary tooth. The most acceptable methods for cavities preparation are the methods of "minimally invasive preparation" and ART-technique.

At the stage of root formation in permanent teeth, enamel and dentin are insufficiently mineralized, tooth cavity has large volume, the horns of pulp are placed close to occlusal surface. In permanent unformed teeth it is advisable to use the "principle of preventive filling" and minimally invasive technique of preparation.

In primary teeth with totally formed roots (stabilization stage), all methods of carious cavities preparation can be applied.

The method of "minimally invasive tooth preparation" and the ART technique should also be used in preparation of carious cavities in primary teeth at the stage of root resorption.

Medical treatment of carious cavities

Medical treatment of carious cavity is an important stage of its preparation for filling. The main tasks of medical treatment of carious cavities are cleaning of the carious cavity from dentin sawdust, oral fluid and other contaminants, bactericidal effect on microflora located in carious cavity.

Medical treatment of carious cavity is carried out according to the following algorithm:

- washing out the carious cavity with water, then with an air-water spray from a water gun and drying with an air gun of dental unit;
- treatment of carious cavity with the 1–2 % Chlorhexidine solution. The Chlorhexidine solution is applied to the bottom and walls of carious cavity for 30–60 seconds and, dried without washing;
- etching the hard tooth tissues and applying adhesive system according to the instruction of appropriate filling material.

For medical treatment of carious cavities in primary and permanent unformed teeth of children, the Chlorhexidine in lower concentrations (0,05–1 %) can be used.

Algorithm for the preparation of I-V classes carious cavities in pri- mary teeth for filling with glass ionomer cement (GIC) and compomers

Material support:

– dental unit;
– turbine handpiece;
– mechanical handpiece;
– diamond heads: spherical, cylindrical (№ 3–5) for turbine handpiece;
– ball-shaped, carbide or steel burs (№ 5–7) for mechanical handpiece;
– kit of dental instruments (probe, mirror, tweezers, excavator, spatula, con- denser-smoother).

Algorithm for performing dental manipulation

№	Action sequence	Control criterion for correct execution
1	**Open up** carious cavity. Carious cavities of the I and II classes are opened from occlusal sur- face, cavities of the III and IV classes – from vestibular or oral surface. Direct access in carious cavities of the II, III and IV classes is used in the absence of an adjacent tooth, the presence of diastema or carious cavity on the contact surface of adjacent tooth. Remove overhanging enamel edges (in cari- ous cavities of the I–V classes) or hard tooth tissues (in carious cavities of the II–IV class- es) using turbine handpiece with cylindrical or spherical diamond heads. The size of diamond head should correspond to	All pathologically altered (demineralized or pig- mented) enamel has been removed. The carious cavity is available for visual inspection
2	Carry out a **necrectomy** of carious cavity. Re- move carious (softened or pigmented) dentin with excavator and mechanical handpiece with spherical burs. Remove softened dentin withn excavator using lever-like movements. In mantle dentin – the recess should be done parallel to the tooth axis, in parapulpar den- tin – in the direction from bottom to walls (at angle of 45° to the tooth axis). Remove more dense carious dentin with spherical bur and mechanical handpiece at low speeds with in- termittent movements in the direction from bottom to walls of the carious cavity	**The visual quality control** In case of moderate caries: the dentin surface on bottom and walls of the carious cavity acquires a natural color and shine. In case of chronic deep caries: it is allowed to leave pigmented dense dentin only at the bottom of carious cavity. The instrumental quality control. Walls and bottom of the carious cavity are dense when probing. In the case of acute deep caries, a small amount

3	Form cavity following the principles of "adhesive	Cavity has free design
4	**Processing of enamel edges** is carried out us- ing polishers or fine-grained diamond heads without	The enamel edges are smooth
Note. If there are two carious cavities on occlusal surface of the second upper temporary molars or the first lower temporary molars, and they are separated by intact enamel ridge, they are prepared and filled separately. It is advisable to combine two cavities into one if there are thin enamel partitions of dubious strength.		

Algorithm for the preparation of class I carious cavities in permanent teeth for filling with amalgam (according to the Black method)

Material support:

– dental unit;
– turbine handpiece;
– mechanical handpiece;
– diamond heads: spherical, cylindrical, cone-shaped (№. 3–5) for the turbine handpiece;
– carbide or steel burs: spherical (№. 5–7), cylindrical, conical, inverted con- ical for the mechanical handpiece;
– carbide burnishers;
– kit of dental instruments (probe, mirror, tweezers, excavator, spatula, condenser-smoother).

Algorithm for performing dental manipulation

№	Action sequence	Control criterion for correct execution
1	**Open up** and **expand** the carious cavity. Re- move the overhanging edges of enamel with turbine handpiece andh cylindrical or spheri- cal diamond heads. The size of diamond head should correspond to diameter of the inlet into carious cavity. Carry out the preventive widening of carious cavity by radical removal of caries-suscepti- ble areas (fissures) to caries-resistant zones (slopes of cusps). The edges of the filling should not fall on the areas of occlusal con-	All pathologically altered enamel (demineralized or pigmented) has been removed. The over- hanging edges of enamel are absent. The cari- ous cavity is available for visual inspection

2	Carry out necrectomy of carious cavity. Re- move carious (softened or pigmented) dentin with excavator and mechanical handpiece with spherical burs. Remove the softened dentin with excavator using lever-like move- ments. In mantle dentin – recess should be done parallel to the tooth axis, in parapulpar dentin – in the direction from bottom to walls of carious cavity (at angle of 45° to the tooth axis). Remove more dense carious dentin with spherical bur and mechanical handpiece at low speeds with intermittent movements in the direction from bottom to walls of carious cavity	The visual quality control. In case of moderate caries: the dentin surface on bottom and walls of carious cavity acquires a natural color and shine. In case of chronic deep caries: it is allowed to leave pigmented dense dentin only at the bottom of carious cavity. The instrumental quality control. Walls and bottom of carious cavity are dense when probing. In the case of acute deep caries, a small amount of light softened dentin is left in projection of the pulp
3	Carious cavity is formed using cylindrical, conical and inverted conical burs or diamond heads. Form carious cavity of box-like shape with flat bottom. In case of deep caries, the bottom may remain concave or be located at different levels. The medial and distal walls of carious cavity should form an obtuse angle of 95–100° with its bottom, the vestibular and oral – acute 80–85°	The form of carious cavity is box-shaped, be- tween its bottom and walls certain angles are saved
4	Processing of enamel edges at an angle of 45° is carried out using polishers or fine-grained diamond heads	The enamel edges are smooth

Algorithm for the preparation of class II carious cavities in permanent teeth for filling with amalgam (according to the Black method)

Material support:

- dental unit;
- turbine handpiece;
- mechanical handpiece;
- diamond heads: spherical, cylindrical, cone-shaped (№ 3–5) for turbine handpiece;
- carbide or steel burs: spherical (№ 5–7), cylindrical, conical, inverted coni- cal for mechanical handpiece;
- carbide burnishers;
- trimmer of gingival margin;
- kit of dental instruments (probe, mirror, tweezers, excavator, spatula, con- denser-smoother).

Algorithm for performing dental manipulation

№	Action sequence	Control criterion for correct
1	**Install** a metal matrix to protect the contact surface of adjacent tooth from accidental damage during preparation	The contact surface of adjacent tooth is protected by a metal matrix
2	**Open** and **expand** the carious cavity from occlusal surface (*oc- clusive access*). Enamel and dentin of carious cavity are removed using turbine handpiece with cylindrical or spherical diamond head. *Direct* access is used in the absence of adjacent tooth or with possible preparation through the carious cavity of	The carious cavity is available for visual inspection
3	Carry out a **necrectomy** of carious cavity. Remove carious (sof- tened or pigmented) dentin with excavator and mechanical hand- piece and spherical burs. Remove the softened dentin with exca- vator using lever-like movements. In mantle dentin – the recess should be done parallel to the tooth axis, in parapulpar dentin – in the direction from bottom to walls of carious cavity (at an angle of 45° to the tooth axis). Remove more dense carious dentin with spherical bur and mechanical handpiece at low speeds with in- termittent movements in the direction from bottom to walls of carious cavity	**The visual quality control** In case of moderate caries: the dentin surface on bottom and walls of carious cavity acquires a natural color and shine. In case of chronic deep caries: it is allowed to leave pigmented dense dentin only at the bottom of carious cavity. **The instrumental quality control** Walls and bottom of carious cavity are dense when probing. In the case of
4	Carious cavity **is formed** using cylindrical, conical and inverted conical burs or diamond heads. Form **the main trapezoidal cavity** with flat bottom. In the case of deep caries, bottom (parapulpar wall) can remain convex. The angle between bottom and pregingival wall of main cavity should be 80-85°. Carry out preventive expansion of main carious cavity in su- cha way that its vestibular and oral walls diverge towards the proximal surface of adjacent tooth and do not contact with it. **An additional box** is formed on occlusal surface by radi- cal preventive removal of fissures and mantle dentin. The ad- ditional box should have flat bottom, the depth of 1.5–2.0 mm (1 mm below the enamel-dentin junction), the width is about 1/3 of the distance between the tops of cusps and the additional box should include all fissures of occlusal surface. The medial and distal walls of carious cavity should form angle of 95–110° with its bottom, the vestibular and oral – 80–85°. The isthmus of transition	The form of main cavity is trap- ezoidal, certain angles between its bottom and walls are ob- served. The additional box is formed on occlusal surface with ob- servance of the corresponding parameters

	The angle (step) between bottom of main and additional surfac- es should be smoothed and equal to 90°. The edges of filling on occlusal surface should not fall into the areas of occlusal contact with the antagonist teeth.	
5	**Processing of enamel edges** at the angle of 45° is carried out using polishers or fine-grained diamond heads without pressure. For the finishing treatment of pregingival wall, it is advisable to use a manual tool - a gum edge trimmer to reduce the risk of gum injury and damage to the enamel of adjacent tooth	The enamel edges are smooth
Note. In case of simultaneous caries lesions of both contact surfaces, one mesio-occlusal-distal cavity (MOD) should be formed. If carious cavity is located under gingiva, it is necessary to carry out the re- traction of gingiva with a retraction cord before the opening of carious cavity.		

Algorithm for the preparation of class I carious cavities in permanent teeth for filling with composite materials of chemical hardening

Material support:
- dental unit;
- dental turbine handpiece;
- dental mechanical handpiece;
- diamond heads: spherical, cylindrical, cone-shaped (№ 3–5) for the turbine handpiece;
- carbide or steel burs: spherical (№ 5–7), cylindrical, conical, inverted coni- cal for the mechanical handpiece;
- carbide burnishers;
- kit of dental instruments (probe, mirror, tweezers, excavator, spatula, con- denser-smoother).

Algorithm for performing dental manipulation

№	Action sequence	Control criterion for correct
1	**Open** and **expand** carious cavity. Remove the overhanging edg- es of enamel with turbine handpiece with cylindrical or spher- ical diamond heads. The size of diamond head should corre- spond to diameter of the inlet into carious cavity	All pathologically altered enamel (demineralized or pigmented) has been removed. The overhang- ing edges of enamel are absent. The carious cavity is available for visual inspection

2	Carry out **necrectomy** of carious cavity. Remove carious (sof- tened or pigmented) dentin with excavator and mechanical handpiece with spherical burs. Remove the softened dentin with excavator using lever-like movements. In mantle dentin – recess should be done parallel to the tooth axis, in parapulpar dentin – in the direction from bottom to walls of carious cavity (at the angle of 45° to the tooth axis). Remove more dense carious dentin with spherical bur and mechanical handpiece at low speeds with intermittent movements in the direction from bottom to walls of carious cavity	**The visual quality control** In case of moderate caries: the dentin surface on bottom and walls of carious cavity acquires a natural color and shine. In case of chronic deep caries: it is allowed to leave pigmented dense den- tin only at the bottom of carious cavity **The instrumental quality control** Walls and bottom of carious cav- ity are dense when probing. In case of acute
3	Form carious cavity with cylindrical and conical burs or dia- mond heads. The bottom of carious cavity should be flat. Ina case of deep caries, the bottom may remain concave or be lo- cated at different levels. The internal contours of carious cavity (walls) should be smoothed, the angles between bottom and walls – rounded. The external contours of carious cavity should be formed tak- ing into account the shape and size of carious defect with min- imal removal of healthy tissues. Edges of filling should not fall into the point of occlusal contact with the	The form of carious cavity is free, with smoothed walls and rounded corners
4	Processing of enamel edges at the angle of 45° is carried out using polishers	The enamel edges of are smooth
Note. Two carious cavities located on occlusal surface of the first upper permanent molars or the first lower premolars, separated by an intact enamel ridge, should be prepared, and then filled each separate- ly. In the presence of thin partitions of		

Algorithm for the preparation of class II carious cavities in permanent teeth for fillings with composite materials of chemical hardening

Material support:

- dental unit;
- dental turbine handpiece;
- dental mechanical handpiece;
- diamond heads: spherical, cylindrical, conical, pear-shaped (№ 3–5) for the turbine handpiece;
- carbide or steel burs: spherical (№ 5–7), cylindrical, conical, inverted coni- cal for the mechanical handpiece;
- carbide burnishers;

– trimmer of gingival margin;
– kit of dental instruments (probe, mirror, tweezers, excavator, spatula, condenser-smoother).

Algorithm for performing dental manipulation

№	Action sequence	Control criterion for correct
1	**Install** a metal matrix to protect the contact surface of adjacent tooth from accidental damage during preparation	The contact surface of adjacent tooth is protected by a metal ma- trix
2	**Open** the carious cavity from occlusal surface (occlusive ac- cess). Enamel and dentin of the carious cavity are removed using turbine handpiece with cylindrical or spherical diamond head. Direct access is used in the absence of adjacent tooth or with possible preparation through the carious	All pathologically altered enamel (demineralized or pigmented) has been removed. The overhanging edges of enamel are
3	Carry out **necrectomy** of carious cavity. Remove carious (sof- tened or pigmented) dentin with excavator and mechanical handpiece with spherical burs. Remove the softened dentin with excavator using lever-like movements. In mantle dentin – recess should be done parallel to the tooth axis, in parapulpar dentin – in the direction from bottom to walls of carious cavity (at the angle of 45° to the tooth axis). Remove more dense carious dentin with spherical bur and mechanical handpiece at low speeds with intermittent movements in the direction from bottom to walls of carious cavity	**The visual quality control** In case of moderate caries: the dentin surface on bottom and walls of carious cavity acquires a natural color and shine. In case of chronic deep caries: it is allowed to leave pigmented dense dentin only at the bottom of carious cav- ity. **The instrumental quality control** Walls and bottom of carious cav- ity are
4	**Form** a carious cavity with cylindrical and conical burs or dia- mond heads. Form a trapezoidal cavity, the bottom may remain concave or multilevel. The internal contours (walls) of carious cavity should be smooth, the angles between bottom and walls – rounded. The vestibular and oral walls should diverge towards the proximal surface of adjacent tooth and not contact them. The angle between bottom and pregingival wall of carious cav- ity should be slightly rounded and be 80–85°. The edges of filling should not fall into the points of occlusive contact with teeth-antagonists. When fissures are affected or to improve the fixation of filling, an additional box can be formed on oc- clusal surface.	The form of carious cavity is trap- ezoidal, with smoothed walls and rounded corners

	Processing of enamel edges at an angle of 45° is carried out using polishers or fine-grained diamond heads without pres- sure. For finishing treatment of the pregingival wall, it is ad- visable to use a manual tool – gum edge trimmer to reduce the risk of gum injury and damage to the enamel of adjacent tooth	The enamel edges are smooth
Note. If carious cavity is located under gingiva, before opening it is necessary to carry out retraction of the gingiva with		

Algorithm for the preparation of class I carious cavities in permanent teeth for fillings with light curing composite materials

Material support:

- dental unit;
- turbine handpiece;
- mechanical handpiece;
- diamond heads: spherical, cylindrical, conical, pear-shaped (№ 3–5) for turbine handpiece;
- carbide or steel burs: spherical (№ 5–7), cylindrical, conical, inverted coni- cal for mechanical handpiece;
- carbide burnishers;
- kit of dental instruments (probe, mirror, tweezers, excavator, spatula, con- denser-smoother).

Algorithm for performing dental manipulation

№	Action sequence	Control criterion for correct execution
1	**Open** carious cavity. Remove the overhanging edges of enamel using turbine handpiece with cylindrical or spherical diamond heads. The size of diamond head should correspond	All pathologically altered enamel (deminer- alized or pigmented) has been removed. The overhanging edges of enamel are ab- sent. The
2	Carry out **necrectomy** of carious cavity. Remove car- ious (softened or pigmented) dentin with excavator and mechanical handpiece with spherical burs. Remove the softened dentin with excavator using lever-like movements. In mantle dentin – recess should be done parallel to the tooth axis, in parapul- par dentin – in the direction from bottom to wallsof carious cavity (at the angle of 45° to the tooth axis). Remove more dense carious dentin with spherical bur and mechanical handpiece at low speeds with	**The visual quality control** In case of moderate caries: the dentin sur- face on bottom and walls of carious cavity acquires a natural color and shine. In case of chronic deep caries: it is allowed to leave pigmented dense dentin only at the bottom of carious cavity **The instrumental quality control** Walls and bottom of carious cavity are dense when probing. In case of acute deep caries, a small amount

3	**Form** a carious cavity with cylindrical, conical and pear-shaped burs or diamond heads. The formed carious cavity can be pear-shaped or has free de- sign, its bottom can remain concave or multilevel. The internal contours of carious cavity (walls) should be smoothed, the angles between bottom and walls	The carious cavity is with smooth walls and rounded corners
4	**Processing of enamel edges** is carried out using polish- ers or fine-	The enamel edges are smooth
Note. In case of two carious cavities located on occlusal surface of the first upper permanent molars or the first lower premolars, separated by an intact enamel ridge, they should be prepared and filled each separately. In the presence of thin partitions of doubtful strength, it is advisable to combine two cavities into one.		

Algorithm for the preparation of class II carious cavities in permanent teeth for fillings with light curing composite materials

Material support:

- dental unit;
- turbine handpiece
- mechanical handpiece;
- diamond heads: spherical, cylindrical, conical, pear-shaped (№ 3–5) for turbine handpiece;
- carbide or steel burs: spherical (№ 5–7), cylindrical, conical, inverted coni- cal for mechanical handpiece;
- carbide burnishers;
- trimmer of gingival margin;
- kit of dental instruments (probe, mirror, tweezers, excavator, spatula, condenser-smoother).

Algorithm for performing dental manipulation

№	Action sequence	Control criterion for correct execution
1	**Install** a metal matrix to protect the contact surface of adjacent tooth from accidental damage during preparation	The contact surface of adjacent tooth is protected by a metal matrix
2	**Open** carious cavity from occlusal surface (occlusive access). Enamel and dentin of carious cavity are re- moved using turbine handpiece with cylindrical or spherical diamond head. Direct access is used in the absence of adjacent tooth or with	All pathologically altered enamel (deminer- alized or pigmented) has been removed. The overhanging edges of enamel are ab- sent. The carious cavity is available for visual inspection

3	Carry out **necrectomy** of carious cavity. Remove car- ious (softened or pigmented) dentin with excavator and mechanical handpiece with spherical burs. Remove the softened dentin with excavator using lever-like movements. In mantle dentin – recess should be done parallel to the tooth axis, in parapul- par dentin – in the direction from bottom to walls of carious cavity (at the angle of 45° to the tooth axis). Remove more dense carious dentin with spherical bur and mechanical handpiece at low speeds with intermittent	**The visual quality control** In case of moderate caries: the dentin sur- face on bottom and walls of carious cavity acquires a natural color and shine. In case of chronic deep caries: it is allowed to leave pigmented dense dentin only at the bottom of carious cavity. **The instrumental quality control** Walls and bottom of carious cavity are dense when
4	**Form** carious cavity by means of cylindrical, conical and inverted conical burs or diamond heads. Form trapezoidal cavity, the bottom may remain con- cave or multilevel. The internal contours (walls) of carious cavity should be smooth, the angles between bottom and walls – rounded. The vestibular and oral walls should diverge towards the proximal surface of adjacent tooth and not contact them. The angle be- tween bottom and pregingival wall of carious cavity should be slightly rounded and be 80–85°. The edges of filling should not fall into the points of occlusive contact with	The form ofcarious cavity is trapezoidal, with smoothed walls and rounded corners
5	**Processing of enamel edges** is carried out using pol- ishers or fine-grained diamond heads without pres- sure. For the finishing treatment of pregingival wall, it is advisable to use a manual tool – gum edge trimmer to reduce the risk of gum injury and damage to the enamel of adjacent tooth	The edges of the enamel are smooth
Note. If carious cavity is located under gingiva, before opening it is necessary to carry out a retraction of the gingiva with		

Algorithm for the preparation of class III carious cavities in permanent teeth for fillings with light curing composite materials

Material support:

- dental unit;
- turbine handpiece;
- mechanical handpiece;
- diamond heads: spherical, cylindrical, conical, pear-shaped (№ 3–5) for turbine handpiece;
- carbide or steel burs: spherical (№ 5–7), cylindrical, conical, inverted coni- cal for mechanical handpiece;

– carbide burnishers;
– diamond coated strips;
– kit of dental instruments (probe, mirror, tweezers, excavator, spatula, condenser-smoother).

Algorithm for performing dental manipulation

№	Action sequence	Control criterion for correct execution
1	Install a metal matrix to protect the contact surface of adjacent tooth from accidental damage during preparation	The contact surface of adjacent tooth is protected by a metal matrix
2	Open carious cavity from the oral or vestibular sur- face (in case of it significant lesion). Direct access is used in the absence of adjacent tooth, the presence of diastema or carious cavity on the contact surface of adjacent tooth. Remove the overhanging edges of enamel with turbine handpiece with cylindrical or spherical diamond heads. The size of diamond head should correspond to diameter of the inlet into cari- ous	All pathologically altered enamel (demin- eralized or pigmented) has been removed. The overhanging edges of enamel are ab- sent. The carious cavity is available for visual inspection
3	Carry out **necrectomy** of the carious cavity. Remove the softened dentin withn excavator using lever-like movements. In mantle dentin – recess should be done parallel to the tooth axis, in parapul- par dentin – in the direction from bottom to walls of carious cavity (at the angle of 45° to the tooth axis). Remove more dense carious dentin with spherical bur and mechanical handpiece at low speeds with intermittent movements in the direction from bottom toe walls of carious cavity	The **visual quality control.** In case of moderate caries: the dentin sur- face on bottom and walls of carious cavity acquires a natural color and shine. In case of chronic deep caries: it is allowed to leave pigmented dense dentin only at the bottom of carious cavity The **instrumental quality control.** Walls and bottom of carious cavity are dense when
4	**Form** carious cavity by means of cylindrical, conical and inverted conical burs or diamond heads. With oral (or vestibular) access, carious cavity of rounded or oval shape is formed. When using direct access, carious cavity should be in the form of trian- gle with rounded angles, the base of which is located at gingival edge. The walls of carious cavity should be smoothed, the angles between bottom and walls – rounded. In case of deep caries, the bottom may remain concave or be located at different levels.	The carious cavity has rounded, oval or triangular shape with smoothed walls and rounded angles

	Intact enamel (particularly on vestibular surface) that is not supported by dentin can be preserved. In case of significant spread of carious cavity on the oral surface of tooth, it is	
5	Form bevel of enamel with cylindrical or cone-shaped diamond heads. Form uniform bevel of enamel at the angle of 40°–45° with a width of 0.5–1.5 mm on the palatal or lingual surface. Form minimal bevel of enamel using strips on the contact surface. The bevel of enamel is not formed in the place where wall of carious cavity is located clos- er to the cutting edge and is in contact with adjacent tooth. On the vestibular surface, an enamel bevel with the width of at least 2 mm with wavy contours is formed. At the pregingival wall it is formed consid- ering	The bevel of enamel is formed on each tooth surface in compliance with the correspond- ing parameters
6	**Processing of enamel edges** is carried out using pol- ishers or fine-grained diamond heads without pres- sure.	The enamel edges are smooth
Note .If simultaneous caries lesions there are on both contact surfaces, which are separated by a suffi- ciently wide area of intact hard tissues, they should be prepared and filled each separately. In case of thin partitions of doubtful strength, it is advisable to combine two cavities into one common additional cavity on the oral surface. If carious cavity is located under the gingiva, before		

Algorithm for the preparation of class IV carious cavities in permanent teeth for fillings with light curing composite materials

Material support:

- dental unit;
- turbine handpiece;
- mechanical handpiece;
- diamond heads: spherical, cylindrical, conical, pear-shaped (№ 3–5) for the turbine handpiece;
- carbide or steel burs: spherical (№ 5–7), cylindrical, conical, inverted coni- cal for the mechanical handpiece;
- carbide burnishers;
- diamond coated strips;
- kit of dental instruments (probe, mirror, tweezers, excavator, spatula, con- denser-smoother).

Algorithm for performing dental manipulation

№	Action sequence	Control criterion for correct execution
1	**Install** a metal matrix to protect the contact surface of adjacent tooth from accidental damage during preparation	The contact surface of adjacent tooth is protected by a metal matrix
2	Open carious cavity from vestibular surface. Oral ac- cess is used less often (if it is possible to preserve intact enamel on the vestibular surface as much as possible). Remove the overhanging edges of enamel with turbine handpiece with cylindrical or spherical diamond heads. The size of diamond head should correspond to diameter of the inlet into carious	All pathologically altered (demineralized or pigmented) enamel has been removed. The edges of carious cavity are within intact enamel. The carious cavity is available for visual in- spection
3	Carry out **necrectomy** of carious cavity. Remove the softened dentin with excavator using lever-like movements. In mantle dentin – recess should be done parallel to the tooth axis, in parapulpar dentin – in the direction from bottom to walls (at the angle of 45° to the tooth axis). Remove more dense carious dentin with spherical bur and mechanical handpiece at low speeds with intermittent movements in the di- rection from bottom to walls of carious cavity	The **visual quality control**. In case of moderate caries: the dentin sur- face on bottom and walls of carious cavity acquires a natural color and shine. In case of chronic deep caries: it is allowed to leave pigmented dense dentin only at the bottom of carious cavity. The **instrumental quality control**. Walls and bottom of carious cavity are dense when probing. In the case of acute deep caries, a small
4	**Form** carious cavity by means of cylindrical, conical and inverted conical burs or diamond heads. Form main cavity of free design with smoothed walls and rounded angles. In case of deep caries, the bot- tom (near the pulpal wall) should convex, to avoid opening the pulp. The angle between bottom and pregingival wall of carious cavity can be straight or sharp, somewhat rounded. With a vestibular approach – the intact enamel on vestibular surface that is not supported by dentin should be completely removed to create conditions for the aesthetic restoration of tooth. In case of the significant size of carious cavity, it is necessary to form an additional box with the depth of 1–1,5 mm and the width of 1,5–2 mm on the oral surface as far as possible from incisal edge. Its pregingival wall must be parallel to gingival edge at the distance of 1–1,5 mm from it.	The form of carious cavity has free design, with smoothed walls and rounded angles. The additional cavity is formed on oral sur- face in compliance with the corresponding parameters

5	Form the **bevel** of enamel with cylindrical or cone- shaped diamond heads. Form enamel bevel of width of 4 mm with wavy con- tours on the vestibular surface. Near pregingival wall it is formed to the full depth of enamel. The width of bevel should decrease towards the incisal edge. On the oral surface, enamel bevel is formed at	The bevel of enamel is formed on each tooth surface in compliance with the correspon- ding parameters
6	Processing of enamel edges is carried out using polishers or fine-grained diamond heads without pressure.	The edges of enamel are smooth
Note. If most of the incisal edge is affected, it should be shortened by 2 mm and covered with composite material. If carious cavity is located under gingiva, before its preparation it is necessary to carry out retraction of gingiva with retraction cord.		

Algorithm for the preparation of class V carious cavities in permanent teeth for fillings with light curing composite materials

Material support:

– dental unit;
– turbine handpiece;
– mechanical handpiece;
– diamond heads: spherical, cylindrical, cone-shaped (№ 3–5) for turbine handpiece;
– carbide or steel burs: spherical (№ 5–7), cylindrical, conical, inverted coni- cal for mechanical handpiece;
– carbide burnishers;
– kit of dental instruments (probe, mirror, tweezers, excavator, spatula, con-denser-smoother).

Algorithm for performing dental manipulation

№	Action sequence	Control criterion for correct execution
1	**Carry out** the opening of carious cavity. Remove overhanging demineralized enamel edges using turbine handpiece with cylindrical or spherical diamond head. The size of diamond head should correspond to diameter of the inlet into carious	All pathologically altered enamel has been removed. The edges of carious cavity are within the intact enamel. The carious cavity is available for visual in- spection

2	Carry out necrectomy of carious cavity. Remove the softened dentin with excavator using lever-like movements. In mantle dentin – recess should be done parallel to the tooth axis, in parapulpar dentin – in the direction from bottom to walls of carious cavi- ty (at the angle of 45° to the tooth axis). Remove more dense carious dentin with spherical bur and mechanical handpiece at low speeds with intermittent movements in the direction from bottom to walls of carious cavity.	The **visual quality control.** In case of moderate caries: the dentin sur- face on bottom and walls of carious cavity acquires a natural color and shine. In case of chronic deep caries: it is allowed to leave pigmented dense dentin only at the bottom of carious cavity. The **instrumental quality control.** Walls and bottom of carious cavity are dense when probing. In case of acute deep caries, a small amount
3	**Form** carious cavity with cylindrical and conical burs or diamond heads. Form carious cavity of kid- ney-shaped or oval shape with smoothed internal contours and rounded angles. The bottom should be convex. Pregingival wall should be parallel to the gingival margin. To improve the fixation of filling, the occlusive and pregingival walls of carious cavity should form the angle up to 45° with its bottom, and the medial and distal – a right angle	The form of arious cavity is kidney-shaped or oval, with smoothed walls and rounded angles
4	**Form the bevel of enamel** with burnishers, cylindrical or cone-shaped diamond heads. In the direction of incisal edge and occlusal surface, enamel bevel is formed for the entire thickness of enamel with the width of 2–5 mm (up to the level of tooth equator). A small bevel is formed on the preg- ingival wall: 0.5–1 mm, on the medial and	The bevel of enamel is formed on each wall of carious cavity in compliance with the rel- evant parameters
5	**Processing of enamel edges** is carried out using pol- ishers or fine-grained diamond heads without pres- sure.	The edges of enamel are smooth

Note. If carious cavity is located under the gingiva, before its preparation it is necessary to carry out the retraction of gingiva

Control questions

1. Name the classification of carious cavities, proposed by Black G.V.
2. List main stages of the preparation of carious cavity.
3. Name modern methods of preparation of hard tooth tissues of children's teeth.
4. What are the basic principles of the preparation of carious cavity? Specify the advantages and disadvantages of each of them.
5. Name the features of preparation of primary and permanent children's teeth, depending on the stage of tooth development.
6. What are the features of preparation and formation of class I carious cavity in primary and permanent children's teeth?
7. What are the features of preparation and formation of class II carious cavity in primary and permanent children's teeth?
8. What are the features of preparation and formation of class III carious cavity in primary and permanent children's teeth?
9. What are the features of preparation and formation of class IV carious cavity in primary and permanent children's teeth?
10. What are the features of preparation and formation of class V carious cavity in primary and permanent children's teeth?

Test tasks to the section "Preparation of carious cavities in primary and permanent teeth"

1. Carious cavity located in blind fossa was found on the palatal surface of the upper lateral incisor during dental examination of an 11-year old child. To what class, according to Black's classification, does this carious cavity belong?

A. I class; B. II class; C. III class; D. IV class; E. V class.

2. 4-year-old child was treated by a dentist for caries in 75 teeth. Sharp excavator of appropriate size was used to remove the light softened dentin. Then the carious cavity was prepared using carbide burs and a mechanical handpiece at low speed. What stage of preparation is described?

A. Processing of enamel edges;
B. Opening of carious cavity;
C. Widening of carious cavity;
D. Necrectomy of carious cavity;
E. Formation of carious cavity.

3. In the permanent upper lateral incisor of 13-year old child, carious cavity, located on the distal contact surface with transition to palatal surface and with lesion of incisal edge was found. It is planned to restore the anatomical shape of tooth with composite filling material. Which variant of the formation of this carious cavity should be chosen?

A. Formation of an additional cavity on vestibular surface;
B. Formation of a retention groove on the incisal edge of tooth;

C. Formation of an additional cavity on palatine surface;

D. Formation of an additional cavity is not carried out.

4. Carious cavity was found on mesial-contact surface of the upper central primary incisor of 4.5-year- old child. Carious cavity was localized in the mantle dentin with a lesion of incisal edge. The vestibular wall of carious cavity is demineralized; its enamel does not have a dentin support. What option of the formation of this carious cavity is advisable to choose when filling with glass-ionomer cement?

A. Formation of a retention groove on the incisal edge of tooth;

B. Formation of carious cavity is not carried out;

C. Formation of additional cavity is not carried out;

D. Formation of additional cavity on the palatal surface;

E. Formation of additional area on the vestibular surface.

5. Carious cavity was found in the second upper permanent molar of 14-year-old child. Carious cavity was located in distal part of the fissure with a transition to the distal contact surface It is planned to restore the anatomical shape of tooth with a silver amalgam. What variant of the carious cavity formation should be chosen in this case?

A. Formation of additional cavity on the buccal surface;

B. Formation of additional cavity on the occlusal surface;

C. Formation of additional cavity is not carried out;

D. Formation of additional cavity on the palatal surface.

6. Two separate carious cavities in the mantle dentin were found in the fissure on occlusal surface of the first temporary molar in 7-year old child. The enamel ridge separating the medial and distal fissures is preserved. Dentist chose glass-ionomer cement for permanent filling of carious cavity. What method of the preparation of carious cavities is expedient to apply in this case?

A. Preparation of two separate cavities on occlusal surface;

B. Preparation of one common carious cavity on occlusal surface;

C. Preparation of separate cavities with transition to contact surfaces;

C. Preparation of carious cavities with output to medial contact surface;

E. Preparation of carious cavities with the output to distal-contact surface.

7. On occlusal surface of the first upper permanent molar in 9-year old child, there is carious cavity in the mantle dentin located in the distal fissure and extending to palatal surface. It is planned to restore the anatomical shape of tooth with light curing composite. What agent should be used for medical treatment of carious cavity?

A. 2 % aqueous chlorhexidine solution;

B. 0.1 % aqueous chlorhexidine solution;

C. 3 % sodium hypochlorite solution;

D. 70 % ethyl alcohol.

8. Carious cavity within the mantle dentine was found on vestibular surface in the precervical region of tooth 63 in 6-year old child. Dentist chose the method of preparation of carious cavity, which involves sequential application of gel into carious cavity for 30 seconds, followed by the removal of affected dentin with special instruments. After preparation of carious cavity, it was filled with glass-ionomer cement. What method of the preparation was used?

A. ART-technique;

B. Mechanical preparation;

C. Acoustic preparation;

D. Chemical-mechanical preparation;

E. Minimally invasive preparation.

9. Carious cavity in the distal fissure was found on occlusal surface of the 26 tooth in 10-year old child. Dentist carried out its preparation only within the affected tissues with special small-sized burs. After that, the carious cavity was filled with light curing composite material with modern adhesive system. What method of preparation was used?

A. ART-technique

B. Mechanical preparation

C. Acoustic preparation

D. Chemical-mechanical preparation

E. Minimally invasive preparation

10. Small carious cavity within enamel was found on occlusal surface of the 36 tooth in separate area of fissures in 7.5-year old child. Dentist chose the preparation method, which involves removing only the affected tissues without preventive expansion of carious cavity. After that, carious cavity was filled with composite material. The intact part of fissures was sealed. What preparation technique was used?

A. ART-technique

B. Mechanical preparation

C. Preventive filling

D. Chemical-mechanical preparation

E. Minimally invasive preparation

Answers to tests to the section "Preparation of carious cavities in primary and permanent teeth"

1—A
2—D
3—C
4—E
5—B
6–A
7—B
8—D
9—E
10—C

Chapter 8

ENDODONTICS OF PRIMARY AND PERMANENT TEETH IN CHILDREN

Diseases of the tooth pulp or periodontium should be treated, it involves manipulations in a tooth cavity. These manipulations are considered in the section of dentistry “Endodontics”.

Endodontics is a branch of dentistry that studies the morphology, physiology and pathology of human dental pulp and tissues surrounding the tooth root (Gutmann J. L.). This is name of the section of therapeutic dentistry, in which therapeutic interventions and techniques of manipulation in the tooth cavity and root canals are described. The correct execution of these manipulations is of great importance in the treatment of pulpitis and periodontium.

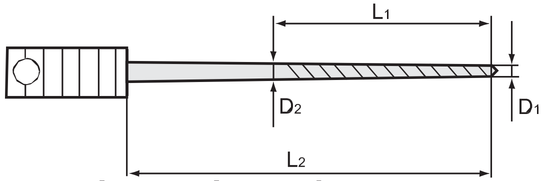
Manipulations in crown part and in root canals of a tooth are performed with the help of special tools. The general principles of structure of an endodontic instrument of a file or reamer type are shown in Fig. 8.1.

Standardization of endodontic instruments is carried out in accordance with the international standard ISO 3630, which regulates the shape, profile, length, thickness, minimum mechanical strength and some other characteristics of standard endodontic instruments. The standard establishes color coding and graphic symbols for different types of instruments.

Main parameters of endodontic instruments in accordance with ISO standard:

– the total length of metal rod (L2) can be 21, 25, 28 or 31 mm. Tools with a rod length of 25 mm are the most common. Tools with a rod length of 31 (28) mm – long tools used for the treatment of frontal teeth, mainly canines; 21 mm – short tools designed for endodontic interventions in mo- lars, primary teeth and in the case of insufficient opening of mouth;

– the length of working part or the length of surface directly in contact with tooth tissues (L1) in most endodontic instruments is 16 mm;



– the size of tool or the diameter of tip of its working part is designated in numbers in

Fig. 8.1. The structure of an endodontic instrument of

a file or reamer type. D_1 – tool size in

hundredths of a millimeter; $D_2 = D_1 +$

0.32 mm; $L_1 = 16$ mm;

$L_2 = 21, 25, 28, 31$ mm

Fig. 8.2. *Color coding of endodontic instruments*

hundredths of a millimeter – from 06 (0.06 mm) up to 140 (1.4 mm). For example, the number 25 means that diameter of the tip of working part of an instrument is 0.25 mm. In addition, the standard provides the color coding of this parameter – tool No. 25 has a red handle. Other tool sizes have the following colors: 06 – pink, 08 – gray, 10 – lilac, from 15 to 40, from 45 to 80 and from 85 to 140 – according to the standard scale (white, yellow, red, blue, green, black) (Fig. 8.2). From 10 to 55, the increase in size of each of the following tools is 0.05 mm, from 60 to 140 – 0.1 mm;

– the conicity of working part according to the ISO standard must be constant. It is equal to 2 % or 0.02 mm per 1 mm of length. This means that every millimeter of the length of working part of a tool increases its diameter by 0.02 mm. In general, the increase of diameter from tip to base of the working part is 0.32 mm. Currently, there are tools with a larger conicity – 04, 06, 08, 10 and 12;
– the graphical representation of tool types is also regulated by the ISO standard. It should be remembered that the symbols do not always correspond to cross-sectional shape of a tool.

It is advisable to consider the instruments used for endodontic treatment, according to their purpose:

1) opening of a tooth cavity and search for orifices:
– drills, endodrills;
– endodontic excavators, endoprobes;
2) removal of soft tissue from a tooth canal:
– barbed broash;
3) extension of the orifices of root canals :
– the drill of type Gates–Glidden;
– the reamer of type Peeso (Largo);
– the expander of an orifices (Orifice opener(widener));

4) formation of root canal :
- for passage of a canal (K-reamer, K-flex);
- to expand and form a canal (K-file, K-flex, NiTi-flex, H-file, rattail-file);
- additional accessories (stops, safety chains with rings or safety threads, which doctor fixes on a finger, devices for placing tools during operation, their storage and sterilization);
- endodontic handpieces;

5) irrigation and drying of a canal:
- endodontic syringes, cannulas;
- absorbent paper pins;
- needles with square cross-section or cutting for fixing of turundas.

6) obturation of a canal:
- canal filler (Lentulo);
- spreader;
- plugger;
- heating plugger;
- special syringes and other devices for introducing of pastes;
- device for hard-core application of gutta-percha (thermafil).

It should be noted that in the beginning, the tools designed for passage of root canals by rotation were called reamers (from the English reamer – a tool that expands the wells), and tools designed to expand canals by scraping up and down – files (from the English file – rasp). Currently, with the appearance of a significant variety of endodontic instruments, including multifunctional, this division is relative.

Tools for opening of the tooth cavity and finding of the orifices of root canals

To remove the roof of pulp chamber, usual drills and diamond heads of different shapes are used. During formation of tooth cavity, cylindrical drills should be used, rather than spherical.

Endodrills are carbide drills or diamond heads of different shape (often cylindrical and conical) with a rounded blunt tip, on which there are no cutting faces or diamond coating (Batt-type of the tip) (Fig. 7.3). The use of such drills, for example, Endo – Z (Maillefer), Endo – Eze (Ultradent), practically eliminates danger of perforation of the bottom of tooth cavity during preparation.

Endodontic excavators differ from the usual one in longer work. They are used to remove crown pulp, tissues changed by caries, dentin chips from the crown part of tooth.

Fig. 8.3. Endodrills

Endodontic probes (endoprobes) resemble standard dental hand probes, but with a longer and thinner working part, which allows them to be used for probing of the orifices of root canals, as well as for removing of denticles from the crown of tooth.

Fig. 8.4. Smooth broashes: *a* – with a round cross-section, *b* – broashes of Miller (faceted), *c* – broashes for fixing of turundas

Smooth broashes can be applied for probing of the root canals. The smooth broashes are divided into smooth, with a circular cross section (Fig. 8.4, *a*), Miller's faceted broashes (Fig. 8.4, *b*) and broashes for fixing of turundas with round cross-section with zigzag cutting (Fig. 8.4, *c*). Diagnostic tools include only smooth broashes (Fig. 8.4, *a*). The other two kinds of smooth broashes are aimed for fixing of cotton turundas and are presented in this section for comparison.

Tools for removing of soft tissue from the root canal

Barbed (nerv) broash is shaped like a rod with approximately 40 spirally placed ridges with a height of 1/2 of the diameter of rod (Fig. 8.5). The ridges are inclined obliquely towards the handle of the tool, have some mobility – when introduced into canal, they are pressed against the rod, and when removed, they effectively cover a soft tissue. The size encoding differs from that used one for files and reamers because the increase of diameter from size to size less than 0.05 mm (0.02–0.04 mm). The length of working part with ridges is about 10 mm, the increase in diameter by 1 mm of length is about 0.01

mm. The graphic symbol of barbed broash is an eight-pointed star with sharp corners.

During operation, a barbed broash is injected into root canal to the required depth. Carefully (effortlessly) rotate it clockwise for 2–3 turns and output together with the contents of root canal. In wide root canals of children's teeth, it is often necessary to introduce several barbed broashes at the same time to remove the massive pulp.

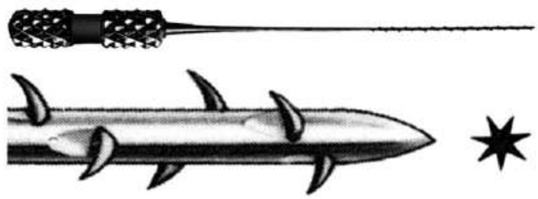


Fig. 8.5. *Barbed broash; general view, working part shape and symbol*

Tools for expanding of an orifice of root canals

Tools for expanding of an orifice of root canals in children are used only in permanent teeth after formation of the root. In primary teeth, the use of these tools can significantly thin the root walls. In permanent teeth with incomplete root formation the orifices of root canal are wide and their additional expansion is not required.

The drill of type Gates-Glidden (*gates – glidden drill, reamer "G"*) has a short teardrop-shaped working part on a long thin rod (Fig. 8.6). The drill has a shank for the angular handpiece (recommended rotation speed – 450–800 rpm). Gates-Glidden is designed to expand the orifice of root canal and its upper third part, which provides good access to the canal. The instruments of this type are often equipped with a safe (blunt) tip. The length of working part with rod is usually 15–19 mm. There are 6 sizes of this tool: 50 (№ 1), 70 (№ 2), 90 (№ 3), 110 (№ 4), 130 (№ 5), 150 (№ 6).

Fig. 8.6. *The drill of type Gates-Glidden*

The Peeso type reamer (*Largo, peeso reamer*) has an elongated working part passing into a rigid rod (Fig. 8.7), and a shank for fixing in the angular handpiece. The Peeso reamer is used in rotary mode (the recommended rotation speed is 800–1200 rpm). The tool is designed for processing of straight and wide canals: straight canals in single-root teeth, palatal canals of the upper molars and distal canals of the lower molars.

Fig. 8.7. *The reamer of type Peeso*

Fig. 8.8. *Orifice opener*

It is used to develop a straight part of a canal, open the orifices, preparation of a canal for the pins. Some tools are equipped with a safe tip. The length of working part with the rod is usually 15−19 mm. There are such sizes of this tool: 70 (№ 1), 90 (№ 2), 110 (№ 3), 130 (№ 4), 150(№ 5), 170 (№ 6). Compared to Gates-Glidden, this tool is more aggressive.

The orifice opener (widener) is a hand or machine tool with a faceted working part that gets narrow uniformly (Fig. 8.8). It is used in rotary mode to expand the orifices and straight sections of a canal. It usually has 3 sizes and 3 lengths (14, 15 and 16 mm).

Tools for passing, opening and shaping of root canals

Type K tools. ***K*** is initial letter of the name of ***Kerr*** company (USA) − the first manufacturer of tools of this type. K-type tools are made by twisting of a metal workpiece with a certain cross-section shape (when twisting metal fibers do not tear, which contributes to the preservation of bending strength). The cross-section is usually of triangular shape (tools with such a cross-section have higher cutting properties, but get blunt faster) or square one. The cross section of tools is more often square up to size 40, and triangular up to 45−140 sizes (to prevent excessive rigidity and increase cutting capacity). The tip angle for standard tools is 75°.

K-reamer. The K-type tool is made of stainless chrome-nickel steel, the angle between cutting face and longitudinal axis is 20° (Fig. 8.9). The number of cutting faces (turns) vary from 17 for small tools to 5 for large ones. The stages of work: penetration, rotation, removal (retraction, during which the instrument cuts den- tin). In a root canal, the K-reamer performs rotational movements no more than 1/4−1/2 of turn clockwise (90−180°). In narrow or curved canals, rotational mo- tion is 1/4 of turn for large reamers. The tool is used to pass root canal along the entire working length of tooth. The graphic symbol is triangle.

K-file. The K-type tool is made of stainless chrome-nickel steel, the angle be- tween cutting face and longitudinal axis is 40° (Fig. 8.10). The number of cutting planes (turns) is larger than in K-reamer (from 33 in small tools to 8 – in large ones), so its cutting capacity is better than in the K-reamer. In a root channel, the tool should move in a vertical direction (up and down). Sometimes its application as a reamer is allowed, however, with a rotation angle, not more than 90°. The main purpose of the tool is to expand a root canal and giving it a shape conve- nient for filling. The graphic symbol is a square.

K-Flex (file) (*K-flex, flexicut-file, Eng. flex means to bend*). The tool combines properties of the reamer and the file, so it can be used for both passing and expan- sion of root canals, especially curved ones. Diamond-shaped cross-section with

concave sides provides high cutting capacity, tool flexibility and the ability to remove dentin chips (Fig. 8.11).

Fig. 8.9. *K-reamer: general view, working part shape and symbol*

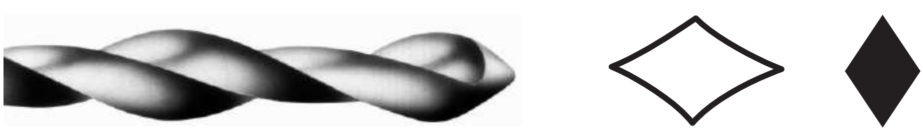
Fig. 8.10. *K-file: general view, working part shape and symbol*

Nitiflex (*NiTiflex*, *Ni-Ti-K-file* is less correct name, because the tool cannot be made by twisting, taking into account the flexibility of workpiece). *NiTiflex*, *Ni-Ti-K- file* – the file made of Nickel-tita- nium alloy (in the ratio of approx, 1:1), which gives the tool extreme- ly high flexibility (5 times greater than in conventional tools) and shape memory. The tool has a safe tip that prevents changes in the anatomical shape of a canal and appearance of ledges. The tool is recommended for treatment of curved root canals. It is necessary to carry out only vertical movements in the canal (up-down). The disadvantage is impossible to pre-bend the tool in accordance with curvature of a canal.

H-file. ***H*** is the initial letter of the name ***Hedstrocm*** – the first manufacturer of this tool. The tool of this type is made of stainless chrome-nickel steel by turning from a round bar (Fig. 8.12). It has the maximum angle between cutting face and longitudinal axis (60°), as well as the largest number of cutting planes (from 31 to 14). This results in greater cutting capacity than in K-tools. At the same time, it has a lower strength, which can lead to breakage, because during the manufacture metal fibers can be torn in places of processing with the cutter. In root canal only vertical movements of the tool are carried out.

It is strictly forbidden to perform rotational movements in a root canal with these tools. Its main purpose is root canal extension and alignment (smoothing) of its walls. The tool of one size smaller than the previous K-file or reamer is usu- ally selected for work. The graphic symbol of the tool is a **circle**.

H-type tools are widely used in pediatric endodontics, because there is a thick layer of infective predentine on the walls of root canal of the teeth in children, which must be carefully removed by applying H-files.



a *b* *c*

Fig. 8.11. K-flex: *a* – shape of the working part; *b* – cross-section; *c* –symbol

Root rasp (*rasp, rat-tail-file*). The structure is similar to the barbed broash, but it has about 50 ridges of 1/3 of wire diameter, lo- cated at right angles to axis of the tool (Fig. 8.13). The ridges of root rasp are strong enough, do not bend and do not break off. The size encoding, as in barbed broashes, differs from the encoding of files and reamers (the increase of di- ameter from size to size is about 0.03 mm, the length of part with ridges is 10.5 mm, and the increase of diameter by 1 mm of length is about 0.016 mm). The symbol is an **eight-pointed star** with right angles. The rasp is designed to re- move contents of the root canal, remove infected predentine and expand a root canal. This tool is used to perform mainly vertical movements in root canal. After that, it is necessary to smooth the walls of canal with K- or H-file.

Fig. 8.12. *H-file: general view, working part shape and symbol*

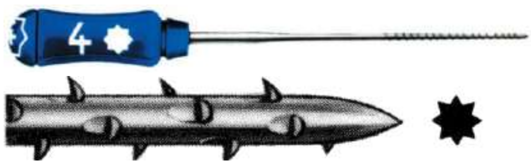


Fig. 813. *Root rasp: general view, working part shape and symbol*

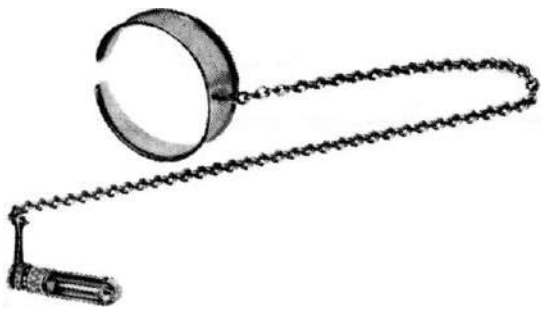


Fig. 8.14. *Safety chain*

Hand endodontic instruments should be fixed to safety chains with rings or to safety threads that are attached to the doctor's finger (Fig. 8.14).

In addition to hand tools, there is also a machine tool, which is driven by spe- cial low-speed endodontic handpieces of different types (Fig. 8.15).

Devices for washing and drying of root canals

Endodontic syringes, cannulas are used for washing of root canal in the pro- cess of its instrumental processing. Use special thin needles with a blunt or closed end and side holes (or hole) or long side bevel or a ledge to avoid pushing of a washing solution outside the top of root (Fig. 8.16). Washing of tooth canals with incomplete root formation should be carried out very carefully, so as not to with- draw the solution beyond wide tip, which can cause damage to the root growth zone.

Paper absorption pins are manufactured in standard sizes corresponding to size of endodontic instruments. They are intended for drying of root canal and introduction of medicines into it. They quickly adsorb blood and biological secrets, maintaining its shape even in the case of full soaking.

Smooth broashes with square or round cross-section and zigzag placed cutting (see Fig. 8.4, *b*, *c*) are designed for fixing of turun- das. With their help, medical treatment and drying of the root canal is carried out.

Tools used for root canal filling

Canal filler (*paste filler*, *root filler “Lentu- lo”*). The design was proposed by French den- tist Lentulo in 1928 (Fig. 8.17). It is a machine (rarely manual) tool with a working part in the form of a centered conical spiral, resembling the anatomical shape of root canal. Spiral turns are twisted counter clockwise, so when a canal filler is rotated, the paste is injected into root canal. The tool is designed for introduction of paste-like filling materials into root canal. The optimum rotation speed is 100–200 rpm. The graphic symbol is spiral.

Fig. 8.15. Endodontic handpieces

Spreader (side compactor of gutta-percha, from English spreader – distributor) – a tool with a smooth cone-shaped working part and pointed tip.

It is designed for lateral condensation of gutta-percha pins in the root canal (Fig. 8.18). Finger spreader is equipped with a handle for the fingers, handle

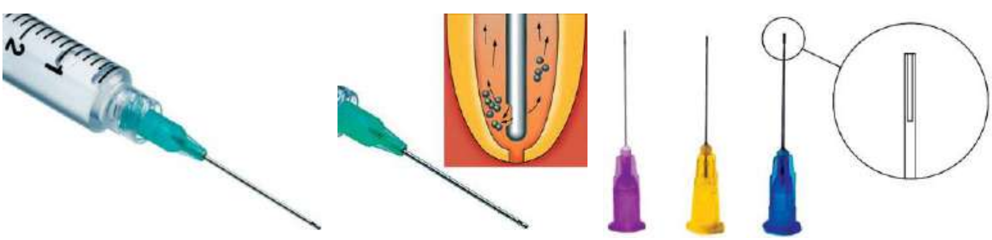


Fig. 8.16. Endodontic syringe and needle

spreader (one-sided or two-siede) – with a handle for holding in the hand. The size of tools is related to size of other endodontic tools. However, there are also spreaders with larger conicity that follow the shape of non-standard gutta-per- cha pins.

Plugger (a vertical compac- tor of gutta-percha, root plugger, plugger, Eng. plug) has a working part in the form of a smooth cy- lindrical or cone-shaped rod with a flattened plugger-shaped top. It is designed for vertical condensa- tion of heated gutta-percha in root canal (Fig. 8.19). *Finger plugger* is equipped with a handle for fingers, *handle plugger* is equipped with a handle for holding in the hand. The sizes of pluggers correspond to sizes of other endodontic tools.

Heat-carrier plugger (*the plug- ger transferring heat*) – the dou- ble-sided tool for vertical conden- sation of heated gutta-percha (Fig. 8.20). It is equipped with two types of working parts: a spreader-type rod, which is heated and intro- duced into the canal to soften gut- tapercha, and a graduated plugger to condense it.

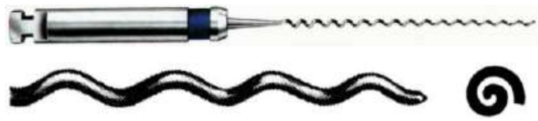


Fig. 8.17. *Canal filler: general view, shape of the working part and symbol*

Fig. 8.18. *Spreader: general view and shape of the working part*

Fig. 8.19. *Plugger: general view and shape of the working part*

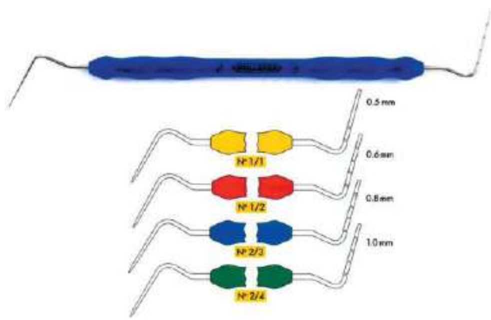


Fig. 8.20. Heat-carrier plugger

There is a significant number of special appliances and devices for filling of root canals with hot gutta-percha (for example, Thermafil system) or paste in form of syringes and similar constructions.

Technique of tooth cavity opening in primary and permanent teeth with unformed roots

The first stage of tooth cavity preparation, providing access to the orifices of root canals, is the disclosure of tooth cavity. This stage is provides:

1) formation of the tooth cavity taking into account its anatomical features: size, shape, number, location and curvature of root canals;
2) creation of the cavity form necessary for convenient carrying out of distant manipulations, which provides:
   – open access to the orifices of canals;
   – direct approach (if possible) to an apical foramen;
   – formation of a canal for a certain planned filling technique;
   – possibility of full control over the direction of expanding tools;
3) removal of residual carious dentin and restoration residues;
4) antiseptic treatment of the cavity. The choice of the shortest access to root canals in all cases is determined by the topographic anatomy of tooth cavity, which in temporary teeth, permanent teeth with incomplete root formation and formed permanent teeth has certain peculiarities.

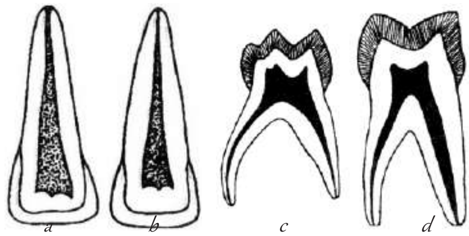


Fig. 8.21. *Differences in the morphology of primary (a, c) and permanent teeth (b, d) (explanation in text)*

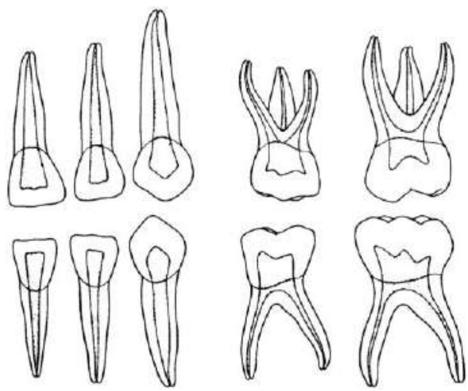


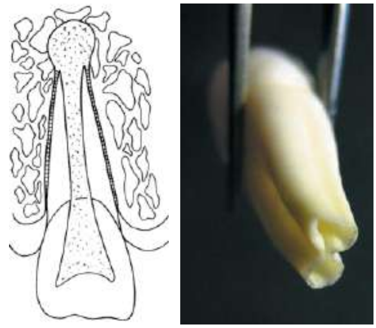
Fig. 8.22. *Topography of tooth cavities in primary teeth*

Primary teeth differ from permanent teeth in a number of anatomical features that are of great importance during endodontic treatment (Fig. 8.21, 8.22):

– smaller size of crowns and roots (compared to permanent teeth);
– less ratio of crown height and root length (long and narrow, flattened roots) than in permanent teeth;
– widely divergent roots of the molars;
– distal inclination of the root apexes of frontal teeth;
– smaller thickness of hard tissues;

– larger tooth cavity size;
– close location of the pulp horns to tooth surface (especially of mesial ones);
– wide cone-shaped canals in single-root teeth;
– gradual change in the topography of tooth cavity due to formation of secondary dentin.

Teeth with incomplete root formation also differ in a number of features of the pulp chamber structure (Fig. 8.23):



a *b*

Fig. 8.23. *Structure of permanent tooth with incomplete root formation: a – a schematic image, b – wide apical foramen in the unformed root*

– the voluminous cavity of the tooth due to a thin layer of dentine, the absence of secondary and replacing dentin;
– absence of marked canal orifices in single-rooted teeth (the crown cavity immediately turns into a wide canal);
– small thickness of dentin of canal walls and low degree of its mineralization;
– presence of a significant layer of low mineralized predentin on the walls of root canal, which is deeply infected in the case of diseases of pulp and periodontium;
– absence of physiological apical narrowing of a canal (the funnel-shaped canal expands to apex, smoothly turning into the growth zone);
– short length of root.

During endodontic treatment the following manipulations can be carried out:

– exposure of a pulp horn;
– disclosure of the tooth cavity;
– pulptomy (removal of only the crown part of pulp);
– pulpectomy (removal of the entire pulp) with adequate access to the root canals with their further instrumental and medical treatment.

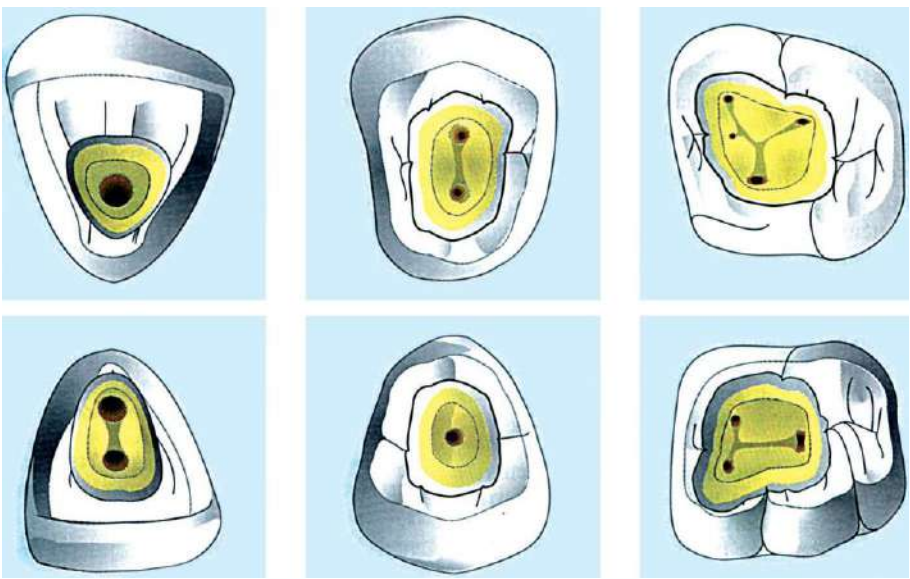
Exposure of a pulp horn is carried out with a sterile spherical drill of medium size, without excessive pressure, with intermittent movements. In incisors this manipulation is carried out in the area of one of its horns (mesial or distal), in canines – towards the most exposed point of crown pulp, located approximately at the intersection of sagittal plane that passes through the incisal cusp, and horizontal plane, which passes through the equator of tooth crown. In premolar the pulp is exposed in the area of protruding buccal horn of pulp; in upper molars – in direction to the mesiobuccal horn of pulp, in lower molars – to lingual horns of pulp.

There are methods of treatment of tooth pulp inflammation, providing its devitalization, at first. After exposure of the pulp horn, a small amount of devitalizing paste is applied to it using a probe (in children a paste based on paraformaldehyde is used), a small cotton ball (dry or impregnated with a local anesthetic solution or a phenol group preparation) and a bandage made of artificial dentin.

Opening of a tooth cavity is carried out differently in teeth that belong to different groups (Fig. 8.24). To create endodontic access, spherical or fissure drills are used, preferably with a safe top (endodrills).

In upper incisors endodontic access is created through the palatal surface: in the central permanent incisor – retreating 2–3 mm from incisal edge in the projection area of root canal orifice; in lateral incisor – in the dental pit area; in lower incisors – through the lingual surface, closer to incisal edge. In temporary teeth the opening of tooth cavity is carried out, as in permanent, but taking into account the smaller size of a crown. The trepanation opening should be wide, its diameter should correspond to the widest part of tooth cavity. Therefore, in temporary and permanent teeth with incomplete root formation, the walls of tooth crown are often significantly thinned during this manipulation, sometimes it is necessary to cut off a part of incisal edge, which complicates a direct access to the root canal.

Tooth cavities of upper and lower incisors correspond in shape to the external configuration of crowns (Fig. 8.25). They are somewhat flattened in vestibular-lin-



a *b* *c*

Fig. 8.24. Opening of the tooth cavity in teeth of different groups: *a* – incisors; *b* – premolars; *c* – molars

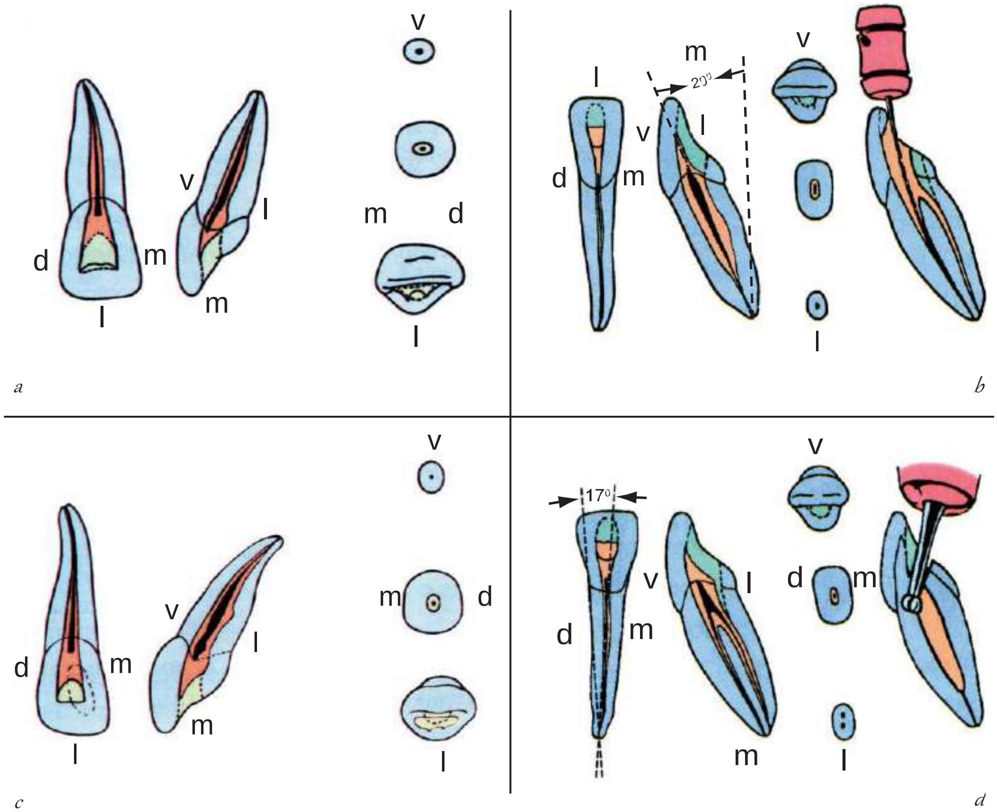


Fig. 8.25*. Opening of the tooth cavity in incisors:

a – upper central, *b* – lower central, *c* – upper lateral, *d* – lower lateral

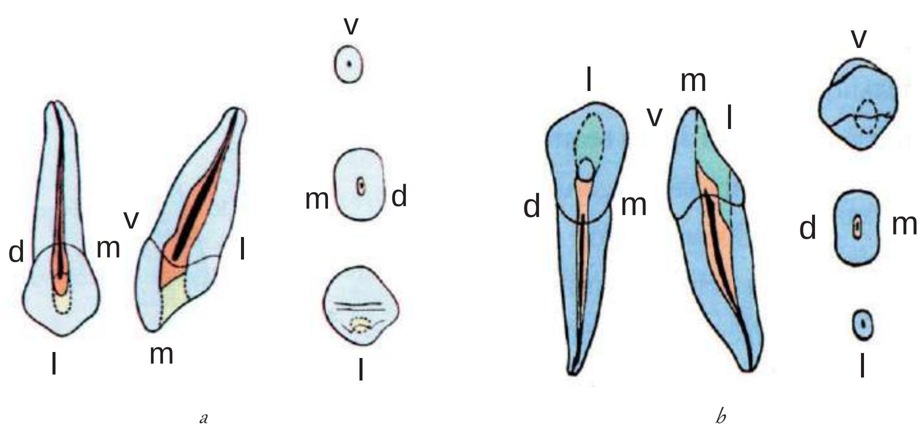


Fig. 8.26*. Opening of the tooth cavity in canines: *a* – upper, *b* – lower

* In Fig. 8.25–8.29 dark color indicates the volume of tooth cavity in an adult (after formation of secondary dentin).

gual direction with weakly marked recessions for the horns of pulp to the corners of crown. The cavity of crown smoothly passes into the root canal. In the lower incisors presence of two root canals – vestibular and lingual – is not excluded. Therefore, when searching for the orifices of canals, cavity should be slightly ex- panded in the vestibular-lingual direction. Sometimes, when opening the cavity of primary incisor, it is more expedient to apply labial access to the root canal. In such cases, a greater expansion of cavity to the incisal edge is carried out to create the most direct access to root canal.

Opening of tooth cavity in canines is carried out from the palatal or lingual surface. To allow penetration into a wide root canal the access must be wide enough. The tooth cavity of upper and lower canines repeats their external shape to a certain extent (Fig. 8.26). In cavity of crown, in the area of its corners and the top of incisal cusp, there are marked recessions for the horns of pulp. Transition of crown cavity into root canal is smooth, without noticeable borders. Opening of tooth cavity in premolar is carried out from the occlusal surface. Endodontic access should have a form elongated in vestibular-oral direction (this provides conditions for finding of the orifices of all canals, if their number is more than one) (Fig. 8.27). Crown cavity repeats the outlines of tooth crown with the horns

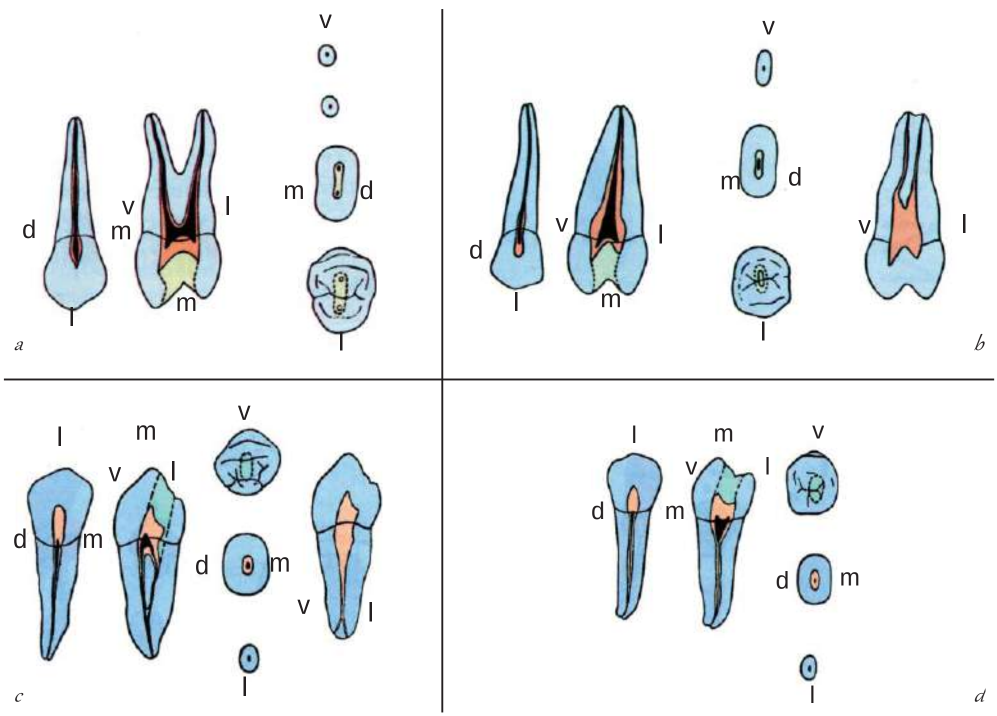


Fig. 8.27. *Opening of the tooth cavities in premolars:*

a – upper first, b – upper second, c – lower first, d – lower second

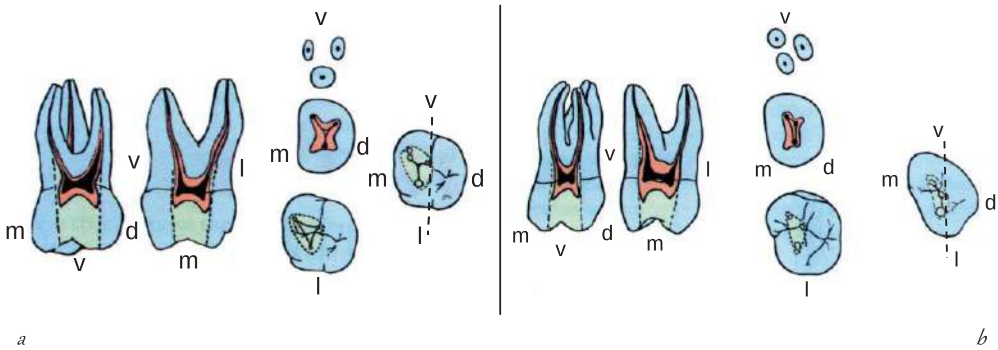


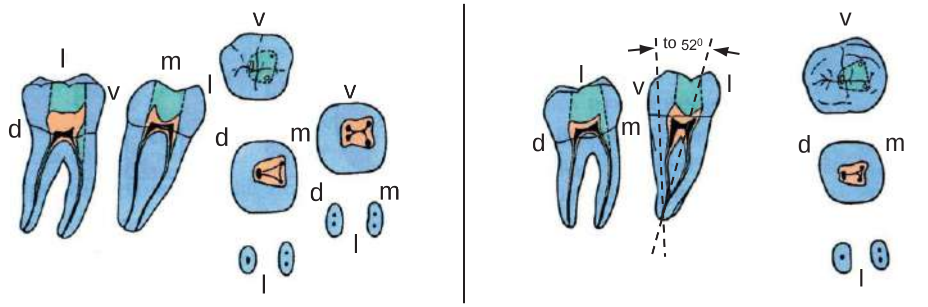
Fig. 8.28. *Opening of the tooth cavity in upper molars: a – the first, b – the second*

of pulp, appearing in the area of cusps of occlusal surface. In the first upper premolar, as a rule, there are two root canals – palatal and buccal, in the second upper and lower premolars – one, although different variants of the structure of their root system are possible.

Creation of endodontic access in upper molar is carried out from the occlusal surface, closer to the medial surface of crown. The bottom of crown cavity has triangle shape with the sharpest angle, which corresponds to the orifice of palatal root canal (Fig. 8.28). Orifices of buccal canals are located closer to each other than to orifice of the palatal root canal. Sometimes along the line connecting me- dial-buccal and palatal canals, you can indicate the orifice of fourth canal, which is located in the mesial buccal root.

At the stage of primary tooth formation, the crown cavity has larger volume than at stages of root stabilization and resorption, and short and wide branches of crown cavity for the pulp horns branch out in the direction of occlusal cusps. At the stage of root resorption, the crown cavity is narrowed in all directions. Branches for the pulp of slit-shaped form branch out in the direction to occlusal cusps. The wall of crown cavity in the stage of root resorption is thickened from occlusal surface, and the root canals are narrowed.

In lower molar endodontic access is created from the occlusal surface, closer to its medial part. The bottom of tooth cavity protrudes towards the occlusal surface. At the bottom of tooth cavity there are holes of three canals: two holes in medial root and one – in distal root (Fig. 8.29). Projection of the distal canal orifice is near the central pit, medial-buccal canal – at the level of apex of the cor- responding occlusal cusp, and the orifice of medial-lingual canal is located in the projection of base of the medial lingual cusp. Tooth cavity resembles its external shape. In the area of arch of crown cavity, there are recessions for the horns of pulp, corresponding to location of the cusps of occlusal surface. The crown cavity of an unformed tooth is more voluminous, and the branches for pulp horns are



a *b*

Fig. 8.29. *Opening of the tooth cavity in lower molars: a – the first, b – the second*

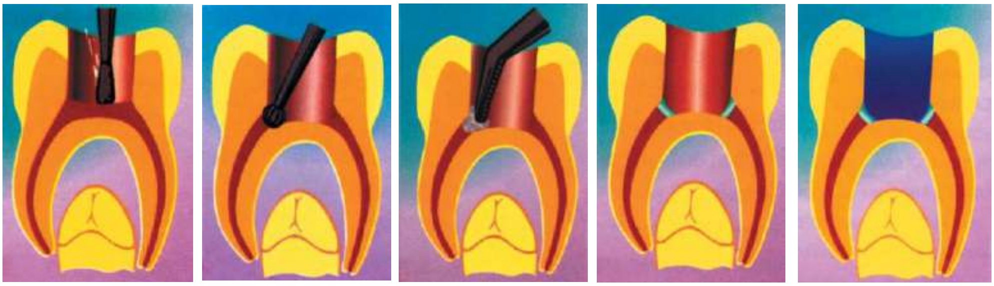
less deep than in periods of root stabilization and resorption. During the period of root resorption in primary tooth, the crown cavity is small, has narrowed and sharply protruding recesses for the horns of pulp.

The main criterion for correct disclosure of tooth cavity is that the endodontic instruments enters root canals freely, without bending. *To do this, the walls of carious cavity or trepanation opening should turn into the walls of tooth cavity smoothly, without ledges.* The orifices of all root canals should be determined vi- sually and with help of a dental probe.

Technique of instrumental and medical treatment of root canals in primary and permanent teeth

For treatment of teeth with inflamed pulp in children, two methods are used – the *pulptomy*, which involves removal of only the crown pulp with following ef- fect on the rest of pulp in root canals with various medications, and the *pulpecto- my* – complete removal of the contents of root canal and its further instrumental, medical treatment and filling.

Pulptomy is performed as follows: after creation of endodontic access (Fig. 8.30, *a*) the crown pulp is removed from crown cavity by cutting it with a spher- ical drill with low speed of rotation (Fig. 8.30, *b*). The pulp stump can be treated with an appropriate drug (formocresol, glutaraldehyde, hemostatic agent) on a cotton ball fixed in dental forceps (Fig. 8.30, *c*). After that, drug applies to the orifices of root canals in which the root pulp remains. On the living pulp in pri- mary and permanent teeth with an unformed root – calcium hydroxide or MTA. On the pulp of primary tooth treated with formocresol – zinc-oxide eugenol paste (Fig. 7.30, *d*), on the devitalized pulp – zinc-oxide eugenol or phenol-for- malin paste. As a filling material glass-ionomer cement uses in primary teeth (Fig. 8.30, *e*), and if necessary – an artificial crown is made (Fig. 8.30).



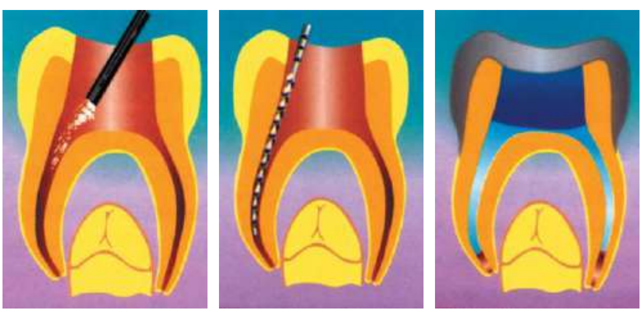
a *b* *c* *d* *e*

Fig. 8.30. *Pulptomy method of pulpitis treatment (explanation in the text)*

Pulpectomy provides treatment and filling of not only crown cavity of tooth, but also root canals (Fig. 8.31).

The root canal conventionally divides into crown, middle and apical parts (thirds). Crown part is usually the widest, attached directly to orifices of root canals. In the apical part, different variants of canal structure are observed, which is associated with the stage of root formation: its narrowing, apical bend, branching (ramification), lateral location of position of apical orifice, fusion of several ca- nals, unclosed apical orifice, root resorption.

In the apical part, near dentin-cement junction, root canal of the formed tooth ends with a narrowing (physiological apical opening), usually located at a distance of 0.5–1.0 mm from the X-ray apex (Fig. 8.32). The extreme point of endodontic intervention in permanent formed teeth should be this physiological narrowing, since the pulp tissue passes into periodontal tissue here. With age, it moves further away from the X-ray apex as a result of the deposition of secondary cement. In teeth with unformed root, the root canal is voluminous, with a wide apical open- ing or with a funnel in the case of unformed apex. In primary tooth at stage of root resorption, the canal is narrow, with a small apical foramen corresponding to it.



a *b* *c*

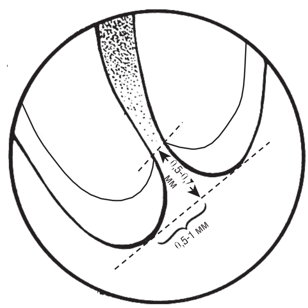


Fig. 8.31. Pulpectomy: medical (*a*) instrumental (*b*) treatment of root canals and their obturation (*c*)

Fig. 8.32. Apical part of the root (*explanation in the text*)

Morphological features of primary teeth, which are important for their endodontic treatment, are given in table. 8.1 and 8.2.

There are conflicting data on the length of permanent teeth, the number of main and additional root canals, their branching in the area of root apex. There are the data of authors who studied teeth of children and adolescents (table 8.3).

Table 8.1

The average length of roots and crowns of primary teeth (Berkovitz BKB et al., 1992)

Jaw	Tooth	Crown height, mm	Root length, mm	Ratio of crown length and root length
Upper	I	6.0	10.0	1:1.7
	II	5.6	10.2	1:1.8
	III	6.5	13.0	1:2
	IV	5.1	10.0	1:2
	V	5.7	11.7	1:2
Lower	I	5.0	9.0	1:1.8
	II	5.2	9.8	1:1.9
	III	6.0	11.2	1:1.9
	IV	6.0	9.8	1:1.6
	V	5.5	12.5	1:2.3

Table 7.8

Anatomy of root system in primary teeth (Schumacher GH, Schmidt H., 1972)

	Age, years	Tooth length, mm	Frequency of detection of different number of root canals, (%)				Frequency of detection of branching in the zone of root apex, (%)	Frequency of detection of different number of additional canals, (%)		
			1	2	3	4		1	2	3
U. I.	3—5	17.0—19.0	100	—	—	—	14	12	4	—
L. I	3—5	15.0—19.0	92	8	—	—	8	10	8	—
U. II	3—5	14.5—17.0	100	—	—	—	16	12	—	—
L. II	3—5	15.0—19.0	92	8	—	—	14	14	4	—
U. III.	5—7	17.5—22.0	100	—	—	—	6	2	—	—
L. III	5—7	17.5—22.0	100	—	—	—	6	4	2	—
U. IV	5—7	14.0—17.0	—	5	19	76	m—5, d—3, p—2	3	2	2
U. V	5—7	17.5—19.5	—	2	15	83	m—8, d—1, p—3	17	2	1

L. IV	5–7	14.0–17.0	–	22	78	–	*m*–8, *d*–9	15	3	–
L. V	5–7	17.5–19.5	–	18	82	–	*m*–9, *d*–5	18	5	–

Table 8.3

Anatomy of root system in permanent teeth

	Age, years	Average tooth length, mm	Frequency of detection of different number of root canals, (%)				Frequency of detection of branching in the zone of root apex, (%)	Frequency of detection of different number of	
			1	2	3	4		1	2
U. 1	10–20	23.7	100				10		
U. 2	12–20	22.1	100				9		
L. 1	12–20	21.8	87	13					
L. 2	12–20	23.3	89	11					
U. 3	16–19	27.3	100				8		
L. 3	16–19	26.0	93.3	6.7			7	13	
U. 4	10–20	22.3	20	80			15		
U. 5	15–20	22.3	100				38		
L. 4	12–20	22.9	100				10		
L. 5	12–20	22.3	100				20		
U. 6.7	15–30	22.3			49	51	m–5,1, d–2,1,		
L. 6	5–17	22.0	2.5	4.5	52.5	40.5	6		
L. 7	18–20	21.7		10.0	72.6	17.4	M–17,7,	13.3	2.3

After creating a direct access to root canals, the pulp is removed using a barbed broash. The instrument should be inserted only in straight part of root canal and not deeper than at 2/3 of its length. After that, the barbed broash is rotated at 1–2 full turns clockwise and carefully removed together with the taken pulp. In teeth with incomplete root formation due to significant volume of pulp it is often necessary to use several barbed broashes for its removal at the same time.

Instrumental treatment of the root canal of formed permanent tooth in- volves the removal of infected predentine from its walls and giving a conical shape to the canal with uniform narrowing. In the case of instrumental treat- ment, 15–50 microns of tissue (the average thickness of infected dentin) are cut from the walls of root canal.

Before the beginning of instrumental treatment of root canal, the ***working length of tooth*** should be determined. *The working length of the tooth* is the dis- tance from physiological tip of root to a certain mark on crown part of a tooth (for

example, tip of cusp on occlusal surface, incisal edge). The working length fixes on endodontic instrument with help of an interlocking disk (stopper). The working length of permanent formed tooth should be 0.5–1.0 mm less than its radiological length.

There are several ways to determine the working length of tooth.

1. *The tabular method* provides for determination of working length of tooth based on average length of individual teeth and their roots, which are given in table 7.1 and 7.2. However, this method is inaccurate, since the individual oscillations can reach 3−5 mm. It can be used only to approximately define the working length of tooth.
2. *The anatomical method.* The ratio of crown length and root length is approximately 1:2 (in permanent canines − 1:2.5). This method can also be used only for approximate determination of the working length of tooth.
3. Determination of the working length of tooth *with diagnostic radiograph*. This method often uses in clinic. The endodontic instrument is tried on to X-ray image of tooth so that its tip does not reach the X-ray tip of root at 1-1. 5 mm, and stopper fixes at the level of the most marked crown part of tooth on the radiograph (incisal edge, cusp of occlusal surface).
4. *The electrometric method* is carried out with an apex locator – a device that records changes in the electrical resistance of tissues when instrument moves in root canal and is withdrawn beyond the tip. The accuracy of de- termining of apical opening location using apex locator is 60−97 %.
5. *Tactile method.* In case of slow movement of the instrument in root canal, its jamming occurs in the physiological apical narrowing. A doctor, who has some experience, will feel it tactically, but will not be completely sure that it is the apical foramen.

Taking into account the shortcomings of all proposed methods of working length of tooth determining, it should be noted that the most accurate, objective and reliable method is a radiograph with endodontic instruments inserted into root canals, the depth of introduction of which is fixed by a doctor.

Determining of the working length of tooth is extremely important when performing endodontic manipulations in children in both primary and permanent teeth, taking into account the instability of root system during the formation of roots or their resorption in primary teeth. The working length of a permanent unformed tooth should be 1.5–2.0 mm less than the X-ray length, length of a primarary tooth – 2,0–3,0 mm less.

Instrumental and medical treatment of root canals should be obligatory, regardless of their diameter and diagnosis, due to it endodontic treatment is carried out.

Tasks of instrumental and medical treatment of root canals are:

– cleaning of root canal from pulp residues or decay, microorganisms, softened infected predentin;
– expansion of root canal and giving it a shape convenient for filling;
– cleaning of root canal walls to ensure a tight fit of the filling material to them.

Rules of instrumental and medical treatment of root canals:

1) mechanical treatment of root canals is carried out with endodontic files. It is necessary to have a kit of high-quality endodontic tools, use it in a clear sequence, adhering to the rules of a certain technique;
2) before starting the mechanical treatment of root canal, it is necessary to determine the working length of tooth;
3) in the process of mechanical treatment of root canal, it is advisable to use means for chemical expansion of root canals − gels-endolubricants. In the course of mechanical processing wash out the canal with an antiseptic solution;
4) as a result of instrumental treatment, the root canal should be expanded by at least two numbers of endodontic instruments compared to its initial diameter;
5) apical part of root canal should be expanded to at least ISO № 25 (in fully formed teeth), as the smaller size does not allow for high-quality cleaning, rinsing and filling of root canal;
6) the main criterion for quality mechanical treatment of root canal is the tactile sensation of presence of dense dentine on its walls and the appearance of light dentin chips;
7) root canal of formed permanent tooth should be given a cone-shaped shape with a funnel-shaped expansion in the area of orifice. In the area of physiological apex it is necessary to form a cone-shaped apical stop. The apical foramen should retain its natural anatomical narrowing.

There are two approaches to canal formation ***of a fully formed permanent tooth:*** apical-coronal (step-back technique) and coronal-apical (crown-down technique).

The step-back technique (“step back” or “from apex to crown”) involves treatment and expansion of root canal in the direction from apical foramen to its orifice, using endodontic instruments from smaller to larger. This technique provides formation of a conical shape of root canal, which repeats its anatomical configuration in an expanded form. To implement the technique, K- and H-files are used, in curved canals the tools are pre-bent in accordance with the shape of canal.

The step-back technique involves several successive stages.

The first stage is passage of root canal along the entire working length. To do this, a thin (08−10 size) K-reamer or K-file is introduced into canal for the working length of tooth, determined earlier and indicated on the instrument by a stopper (Fig. 8.33, *a*).

The second stage is formation of the apical stop necessary to prevent removal of gutta-percha pins or endosealant beyond the apical foramen. This step begins by applying a K-file of the same size as tool that moved through a root canal along the entire working length. K-file should be used to carry out movements of the type "winding" of mechanical watches (Watch-Winding) – easy rotations at 90° clockwise and counter clockwise to expand the apical part of root canal. Continue working with a tool of this size, until it passes through the canal freely.

Then the same procedure is carried out for the next (larger) size. After reaching the free movement of this file in a canal, control passage of a canal with tool of the previous (smaller) size is carried out (to prevent blocking of an apical fo- ramen by dentin sawdust). Consistently increasing the size of endodontic instru- ments, the apical part of root canal is expanded by 3−4 sizes from the initial size of instrument, but not less than to № 25 (the minimum file size that provides treatment of apical part of a canal sufficient for good cleaning and obturation) (Fig. 8.33, *b−d*). The approximate sequence of sizes of tools: 10–15–10–20–15–25–
20. If, at first, the size of tool, which reaches a top, is bigger than 25 (which often happens in children), it is necessary to expand the apical area by 1−2 sizes to form an apical stop for the gutta-percha pin. The file that completed formation of an apical stop, is called the main, or master file (Master-file).

The third stage is instrumental treatment of the apical third of root canal. Upon completion of processing of the apical part with tool № 25, the tool No. 30 is insertsd into canal, the working length of which is 1 mm less than the last apical file (Fig. 8.33, *e*). Upon completion of the work of this tool, it is necessary to carry out so-called recapitulation − control treatment with the last apical file (№ 25) to smooth the formed "steps" and prevent clogging of a canal with den- tine chips. After file № 30 use file № 35, the working length of which is less than the working length of tooth by already 2 mm (Fig. 8.33, *f*), then file № 40, which is smaller by 3 mm (Fig. 8.33, *g*) and so on (Fig. 8.33, *h*, *k*). After using a tool of each size it is necessary to perform recapitulation using the master-file or H-files. At each stage of instrumental treatment, the root canal is washed with an anti- septic solution.

The fourth stage is formation of the middle and orifice parst of root canal, which consists in giving it a cone-shaped shape for further medical treatment and filling. This step can be performed with Gates Glidden drills or orifice expand-

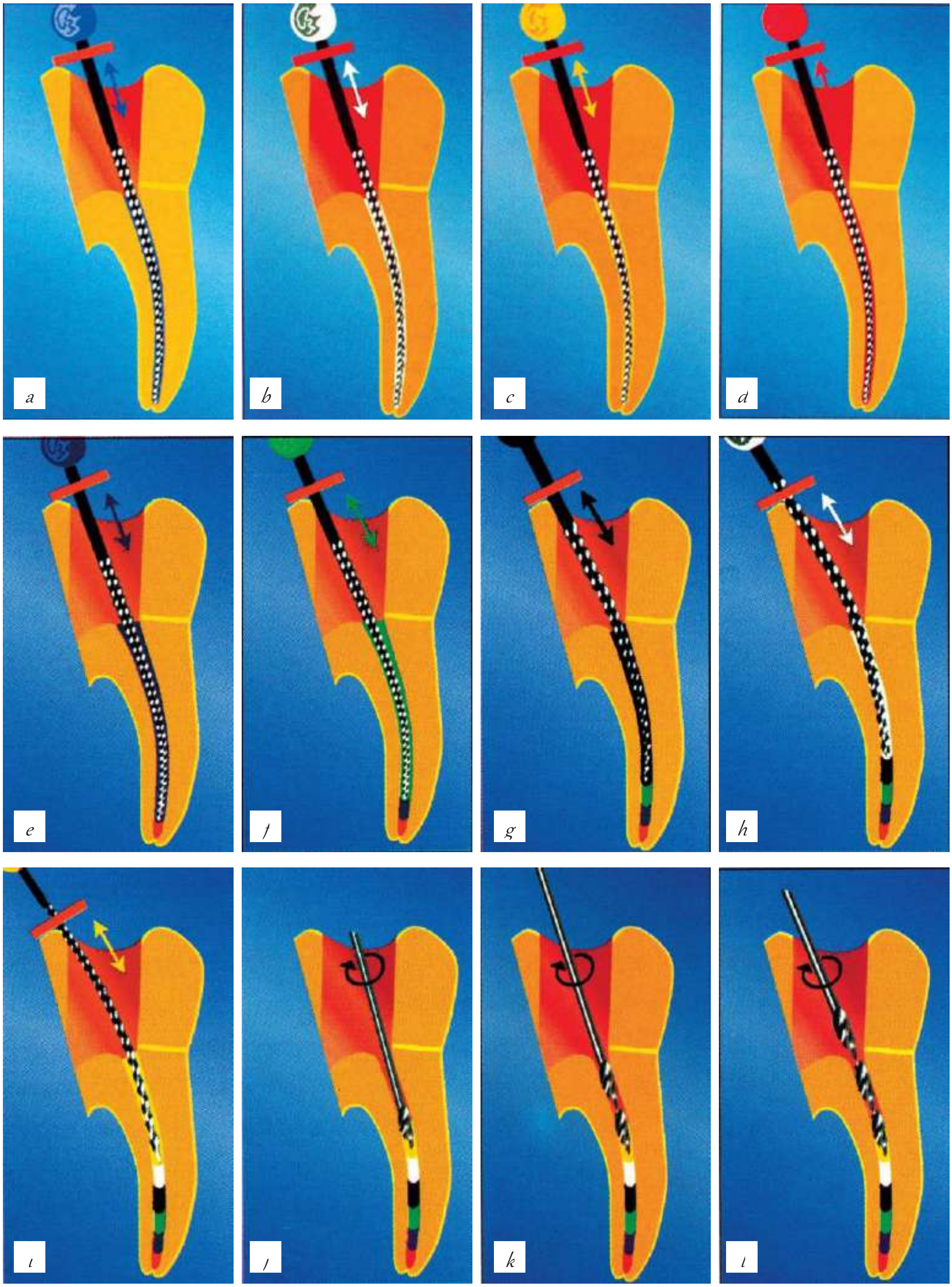


Fig. 8.33. *Treatment of root canal using the step-back technique (explanation in text)*

ers. They are applied successively from smaller size to larger one, treating only straight sections of the root canal (Fig. 8.33, *l, m*).

The fifth stage is alignment of walls of a root canal. In root canal reciprocating movements are performed along the entire working length of tooth with H-file, one size smaller than master-file. Align and smooth the walls of root canal, giving it a conical shape.

Disadvantages and possible complications of the apical-coronal technique are: probability of pushing infected tissues behind an apical foramen or creating an apical blockade with dentine chips; uncontrolled change of the working length of tooth due to expansion and partial straightening of canal curvature during its treatment; possible change the direction of channel and location of an apical foramen due to rigidity of tools.

The step-down or crown down technique involves the treatment and expansion of root canal from mouth to apical foramen, using tools from larger to smaller. First, the oral and middle thirds of root canal are expanded, then the working length of tooth is determined, after which the apical part of canal is treated and an apical stop is created. This technique reduces risk of pushing the infected material into apical zone and beyond a top of root by first removing necrotic masses from the crown part, creating sufficient conditions for high-quality irrigation of canal, the possibility of better control over treatment of an apical part by initially creating good access to it, reducing the danger of expanding of an apical opening. The method is effective in impassable or previously poorly filled channels. The work- ing length of tooth can be determined not before the treatment of canal, but after providing access to the apical third, after partial expansion and straightening of a canal, which gives more accurate results.

The technique of canal treatment with crown down technique provides several stages.

The first stage – placement of K-file № 35 into root canal to a depth of 16 mm (Fig. 8.34, *a*). If the tool of such size cannot be entered at once, enter smaller one and expand a root canal until file № 35 can be entered to a depth of 16 mm. The file is used until there is a free movement in a canal for a fixed length. Only the top of tool works, so it can be rotated two turns clockwise without pressure. Then the canal is treated with Gates-Glidden drills No.1 and 2 for the same length.

The second stage is to determine the “temporary” working length of tooth (it is approximately 3 mm less than the final one). For this purpose, a diagnostic X-ray with endodontic instrument inserted into root canal is used.

The third stage is the passage of apical part of root canal to the “temporary” working length. K-file № 35 is inserted into root canal until it stops, turned two full turns clockwise and removed from the root canal. Then in the canal, K-file

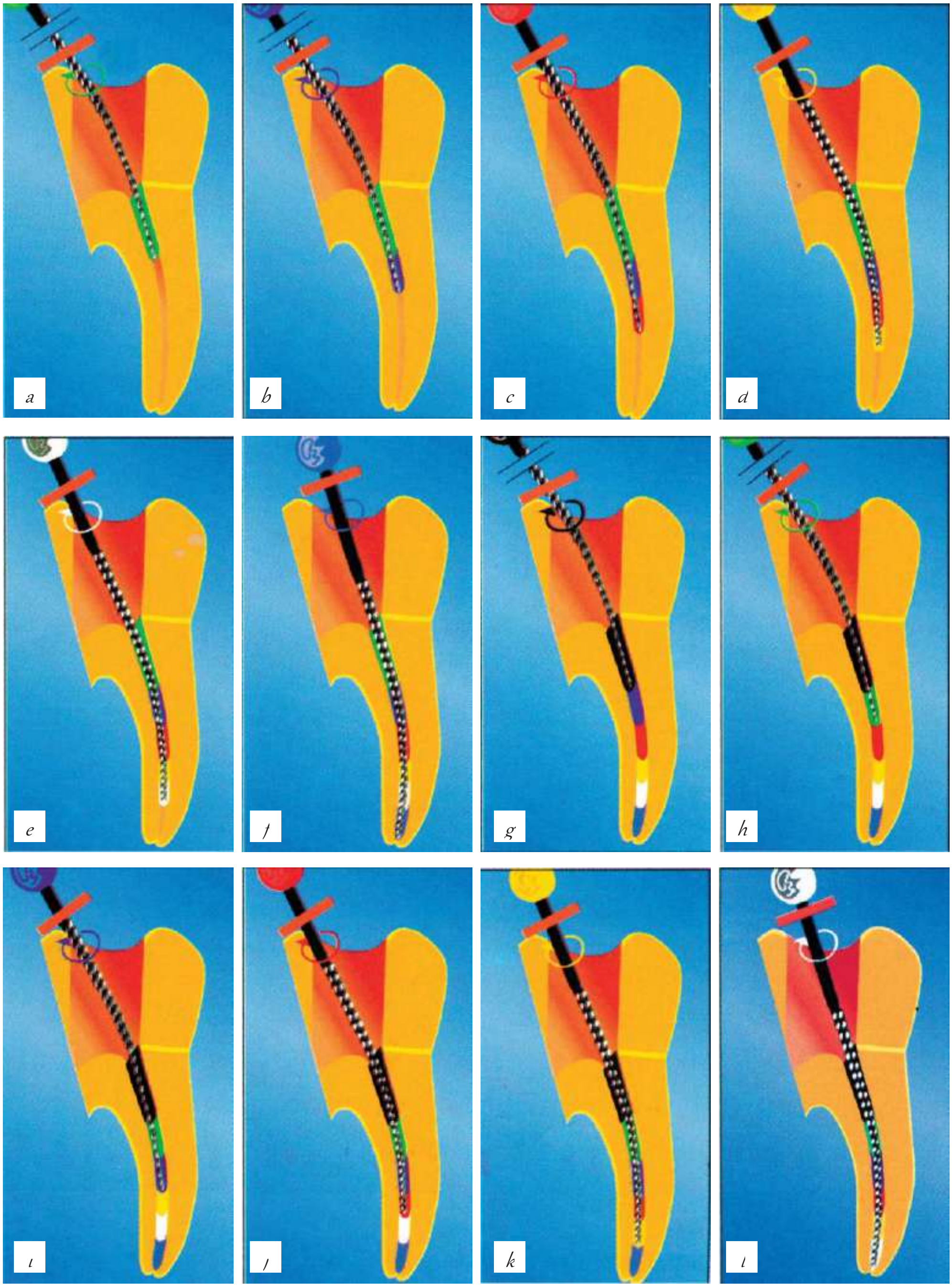


Fig. 8.34. *Treatment of root canal using the crown down technique (explanation in text)*

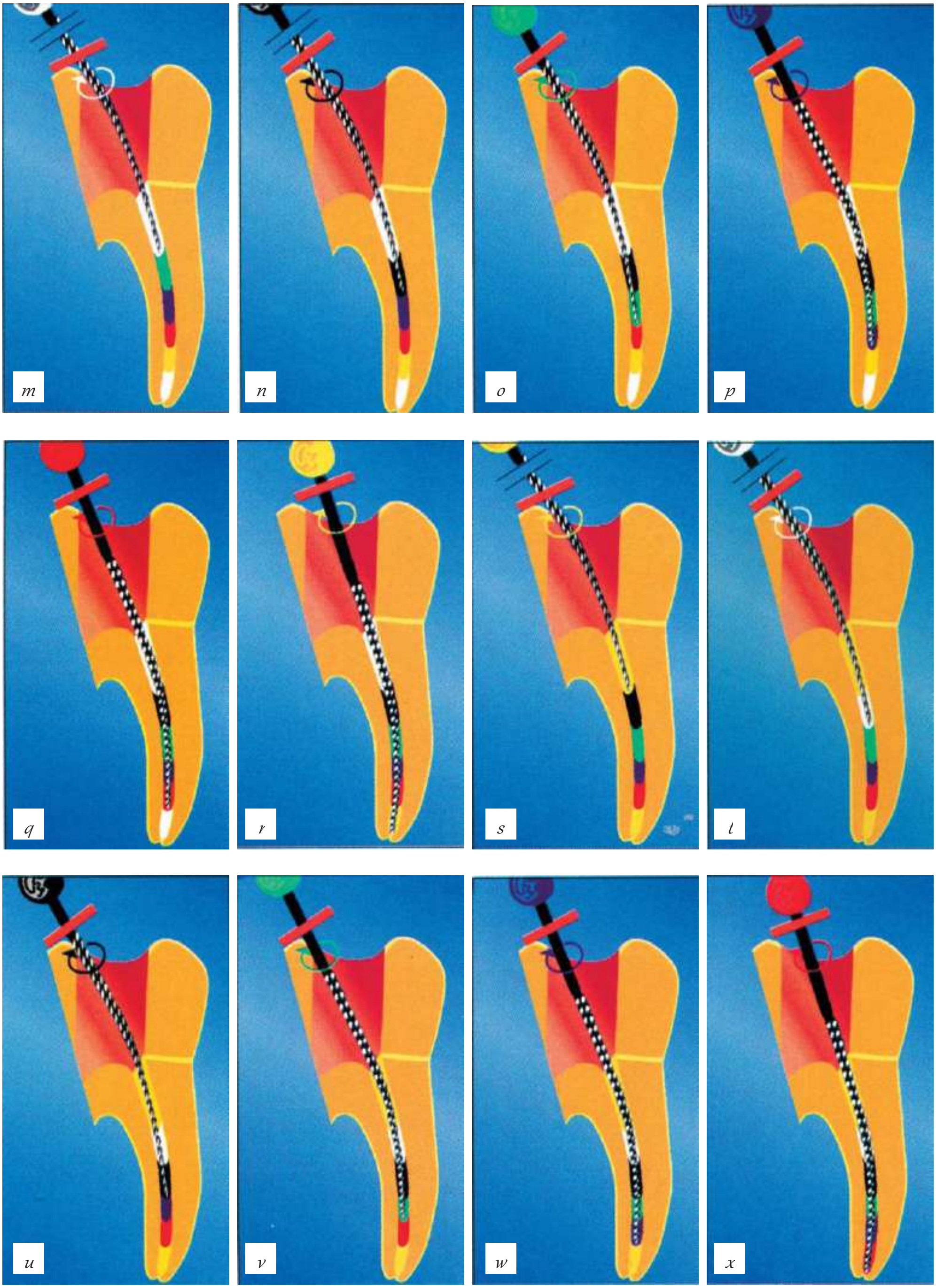


Fig. 8.34. Continuation

№ 30 is entered until it stops and gently rotated clockwise, pushing as much as possible in the apical direction (until you feel a slight jamming) and removed from canal (Fig. 8.34, *b*). The same treatment is carried out with K-file № 25 (Fig. 8.34, *c*) and further smaller ones, reaching a "temporary" working length (Fig. 8.34, *d−f*).

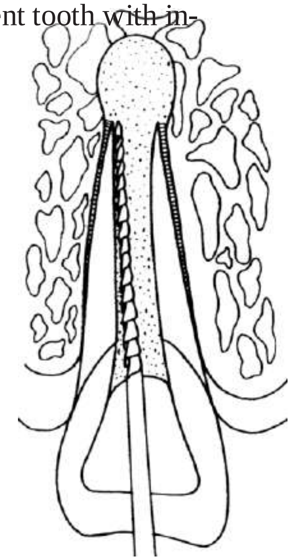
The fourth step is to determine "final" working length. To do this, a diagnostic X-ray is performed with an endodontic instrument inserted into the root canal (for a "temporary" working length).

The fifth stage is expansion of root canal. Start with placement of K-file No. 40 into root canal until it stops, make two full turns of the tool clockwise and remove it from canal (Fig. 8.34, *g*). Successively, a root canal is treated with smaller files (№ 35, 30, 25, and so on, Fig. 8.34, *h−m*), pushing them as far as possible in the apical direction, reaching "final" working length. After passage of a canal along all working length, the manipulation is carried out repeatedly, but starting with the tool of bigger size (№ 45) (Fig. 8.34, *n*). Instrumental treatment of root canal is continued until the apical part is developed to size 25 or other de- sired diameter. The walls of root canal are aligned with H-files. Approximate se- quence of work with endodontic instruments of different sizes when using crown down technique: № 35 (to the stop, maximum – 16 mm) – № 30 (to the stop) – № 25 (to the stop) – № 20 (to the stop) – № 15 (to the stop). If we assume that the tool size 15 has reached the working length, the further sequence of work will be as follows: № 40 (to the stop) – № 35 (to the stop) – № 30 (to the stop) − № 25 (to the stop). If the tool № 25 reaches the full working length, tool processing can be stopped, if the tool has not reached – repeat again, starting from size № 50. The technique makes it possible to form a canal with a predominantly rounded cross-section, since the rotation technique ("reaming") is mainly used. Therefore, there may be difficulties in performing this technique in canals with a cross-sec- tion that is very different from the rounded one (these problems are deprived of the apical-coronal technique, mainly filing is preferably used). Taking into ac- count the complexity of crown down technique, it is more often used to expand root canals with machine nickel-titanium tools: profiles, GT files, protapers, etc. **Hybrid techniques of root canal treatment** are different combinations of two previous techniques. Begin processing of root canal from the orifice part, as in the crown down technique, then, reaching the top, modify canal with *the step-back technique*.

During **the instrumental treatment of root canals** of primary teeth, do not strive to give them a marked conical shape, taking into account the danger of thinning of already thin walls. In these cases, it is sufficient to remove an infected predentine from walls. This method of instrumental processing, when root canal is processed along the entire working length with tools, their diameter gradually increases, without creating a significant conicity, **is called standardized**. Step- back and crown-down methods of instrumental treatment of root canals, which are used in formed permanent teeth, they are ***not used in primary teeth***.

To calculate the working length of primary tooth from its radiological length 2–3 mm are subtracted (remember that in a permanent formed tooth 0.5–1 mm, the average distance from radiological apex to physiological apical narrowing, are subtracted). This distance to the top of root prevents possible injury of periodon- tal tissues and the germ of a permanent tooth. In primary teeth, instrumental treatment consists in widening of canals along the entire working length by 2–3 tool sizes. In primary molars, the canal is treated to an average of 25–30 size, in frontal teeth – up to 100, perhaps more (taking into account the very wide canals). The tips of instruments form an apical stop at distance of 2–3 mm from the X-ray tip of tooth, which further prevents removal of filling material outside a canal. Re- moval of infected predentine from walls of a canal and its expansion is performed with H-files, which are carried out by vertical scraping movements ("filing"). Rimers are used very rarely – only for passage of very narrow, difficult-to-pass canals, which happens infrequently in children. Instrumental treatment of canals in primary teeth should be carried out with extreme caution because of thin walls of a canal, less mineralization of dentine and a wide apical opening.

Instrumental treatment of root canals of permanent teeth with incomplete formation of roots also does not provide for the creation of cone-shaped different shapes due to thin walls of a canal and the lack of apical closure of a canal. To cal- culate the working length of a permanent tooth with in- complete root formation, 1.5–2 mm is subtracted from its radiological length to prevent injury to the growth zone at the top of root.



Stages of the standard technique of root canal treat- ment in a permanent tooth with unformed root:

1) passage of root canal after determining of the working length of the tooth. The root canal is passed by K-reamer or K-file, the working length of the tooth is previously fixed on endodontic in- struments with stopper;
2) removal of infected predentine from the walls of root canal. The canal of a permanent tooth with incomplete root formation is treated with K- and H-files of large size with safe tip (Fig. 8.35). In- struments scrape the infected predentine from walls of root canal

with vertical movements. In process of instrumental treatment, the root canal

Fig. 8.35. *The instrumental treatment of root canal in unformed tooth*

is constantly washed with an antiseptic solution. Giving conical shape to the canal is not necessary, taking into account its thin walls and unformed tip.

The agents used for **medical treatment** (washing) of root canals should have bactericidal effect on microorganisms that are in a root canal, penetrate into dentine tubules and clean the macrocanal from organic residues, be safe for periapical tissues and the body as a whole. For medical treatment of root canals during endodontic treatment, a variety of medications are used. In everyday practice, most often 1‒5 % solution of sodium hypochlorite, 2 % solution of chlorhexidine, 3 % solution of hydrogen peroxide, etc. are used. During mechanical processing of root canal it is necessary to wash out it constantly (irrigation) to clear of dentine chips, the residues of soft tissues, dissolve organic decay, for the purpose of disinfection (of both the main, and additional canals) and to facilitate the movement of an endodontic tool in root canal. For this purpose, substances of the group of oxidants are most often used. The combination of instrumental processing and action of these agents is often called *chemomechanical processing*. Solution of so- dium hypochlorite (NaOCl) of low concentration (in children – 0.5–1 %) is most often used as an irrigation agent for root canals. This substance has antiseptic properties and can dissolve organic residues in a root canal. The 2 % chlorhex- idine solution or other non-irritating antiseptic agents can also be used to treat root canals in children.

Methods of medical treatment of root canals of teeth

1. *Antiseptic treatment with paper pins* impregnated with a drug solution (usually strong antiseptic, such as phenol, cresol, formalin) (Fig. 8.36).
2. Washing of a root canal with drug solution using *an endodontic syringe with special needle* with a blunt or closed end and a side hole. The needle should not reach the top of root by 2 mm, and high pressure should not be created in a canal to prevent penetration of liquid beyond it through the wide apical foramen.
3. Washing of root canal with solutions of drugs *using ultrasound*. Ultrasonic treatment due to the hydrodynamic effect allows cleaning of those parts of root canal that are not available for processing with hand tools and when washed with an endodontic syringe and needle.

Fig. 8.36. *Absorption paper pin*

Filling materials for temporary and permanent root canal obturation

Temporary obturation of root canals of teeth is filling of canals with non-hardening plastic material having certain therapeutic properties (antiseptic, anti-inflammatory, stimulating regeneration and formation of bone and cement) for a period of several days to several months with further replacement with a permanent filling material. Temporary obturation is used for additional drug action on the root canal and periapical areas of bone. Temporary obturation can be short-term (up to several days) or long-term (up to several months). For temporary obturation, pasty materials are used that fill the canal well and provide a sufficient level of concentration of the drug during entire time of obturation. The placement of paste-like agents into a root canal for temporary obturation is carried out with canal filler or through syringe needle. Sometimes, a paper absorption pin with drug is inserted into a root canal for therapeutic action, followed by closure of the endodontic access with a temporary filling material. However, this method of temporary obturation is usually not effective because of low concentration of the drug in a root canal.

Several types of non-hardening pastes are used for temporary obturation of root canals: pastes based on long-acting antiseptics, pastes with calcium hydroxide, pastes with antibiotics and corticosteroids, pastes with metronidazole. In the practice of pediatric therapeutic dentistry for temporary obturation of root canals, especially in permanent unformed teeth, pastes based on calcium hydroxide are often used. These drugs are aqueous suspensions of calcium hydroxide and are used as an intracanal drug in the case of treatment of destructive forms of periodontitis, cystogranuloma and radicular cysts, as well as to stimulate the processes of root apexification (closure of the apical foramen).

Pastes containing a combination of calcium hydroxide and iodoform can be used for the same purpose. Calcium hydroxide provides an osteotropic effect and iodoform – a long-term antiseptic effect.

The purpose of permanent filling (obturation) of root canals is to fill entire canal system, obturating not only the apical area of root, but also dentine tubules and additional canals to prevent the passage of microorganisms and fluid along a root canal.

Materials for permanent obturation of root canals are:

- plastic hardening materials (sealers) based on Zinc oxide and Eugenol, calcium compounds, polymers and resins, phenol-formalin, and glass-ionomers;
- hard materials (fillers): gutta-percha, silver pins.

Materials used for permanent filling must meet the following requirements:

1) be easily inserted into a root canal;
2) slowly harden (from 1 to 12 h);
3) fit tightly to canal walls, ensuring tightness of the filling;
4) after solidification, form a dense, homogeneous mass without air-bubble voids;
5) do not dissolve in a root canal, but dissolve when removed beyond the top of root;
6) if necessary, it can be easily removed from a root canal;
7) provide antiseptic and antiinflammatory effect, promote regeneration of periapical tissues;
8) not to cause periodontal irritation;
9) not to have toxic, allergenic, mutagenic and carcinogenic effects;
10) not to stain hard tissue of a tooth;
11) not to break the adhesion, marginal fit and solidification of permanent filling materials.

The materials that fill root canal during its permanent filling are called ***root fillings.***

Plastic hardening materials can be used as independent fillers or act as a root sealant (sealer), filling space between the filler (gutta-percha, pins) and the walls of channel.

The use of pastes and cements without solid fillers has a number of shortcomings: complexity of dense homogeneous filling of root canal; possibility of uncontrolled removal of material beyond the apical foramen in case of excessive pressure; shrinkage of material proportional to its volume; possibility of washing out and its resorption before and after solidification.

Independent use of pastes for root canal obturation is desirable in temporary teeth, since the filling material must dissolve together with the root of temporary tooth. The solid filler (gutta-percha) with a sealer is mainly used for obturation of root canals in permanent teeth. Sealers (endosealants) (from the English to seal – sealing) are hardening materials designed to fill the gaps between pins and walls of root canal and ensure the integrity of root filling.

Plastic hardening materials for permanent obturation of root canals are divided into several groups:

1) based on Zinc oxide and eugenol;
2) based on epoxy resins and polymers;
3) hardening materials that contain calcium hydroxide;
4) glass-ionomer cements.

Materials based on Zinc oxide and eugenol

The materials based on Zinc and eugenol are represented by powder (Zinc oxide with different additives that improve the quality of material) and liquid (eugenol or clove oil). They harden in a tooth cavity for 12‒24 hours under the influence of moisture and temperature to form insoluble salt (Zinc eugenolate). Zinc oxide eugenol cements are highly effective endosealants. They are used for filling of root canals with gutta-percha pins and independently.

Advantages of group I materials:

– antibacterial and anti-inflammatory effect due to eugenol;
– after solidification, the insoluble mass is formed, which does not shrink and adheres tightly to walls of a root canal;
– dissolve when removed from the top of root;
– optimal solidification time (several hours);
– if necessary, can be easily removed from the root canal.

Disadvantages:

– possible leaching from the canal due to gradual solubility;
– long-term preservation of cytotoxic properties due to eugenol;
– possibility of sensitization to phenol;
– possible change of a tooth color;
– low strength and probability of slow resorption in a root canal;
– can disturb the hardening process of composite materials.

Materials of this group include Endomethasone (“Septodont”, France), Tubliseal, Cariosan (“Spofa Dental”, Czech Republic) etc.

Materials based on epoxy resins and polymers

Materials of the second group are made on the basis of epoxy-amine polymers or copolymers of acrylic and epoxy resins with addition of X-ray contrast fillers. They are produced mainly in the form of “paste/paste”, harden after mixing for 8‒36 hours.

Materials based on epoxy resins are endosealants (sealers) should be used with gutta-percha pins only.

The advantages of endosealants of the second group:

– plasticity;
– easy introduction to a root canal;
– long solidification time in a root canal;
– low shrinkage;
– low solubility after solidification;

– high radiopacity;
– good fit to the walls of root canal;
– thermal stability (can be used with preheated and thermoplasticized gutta-percha);
– do not disturb the hardening process of composites.

Disadvantages:

– cytotoxicity (over a relatively long solidification time);
– question of possible mutagenicity and allergenicity of epoxy resins is dis- cussed.

Materials of the second group include: Viedent, AH +, ThermaSeal (epoxy resins).

Solidifying materials containing calcium compounds (calcium hydroxide and hydroxyapatite)

Materials of the third group are polymeric compounds to which calcium hydroxide compounds are additionally introduced.

Their advantages:

– devoid of irritating properties of Zinc oxide-eugenol cement;
– high biocompatibility and osteogenic effect on the periapical bone and tooth cement.

Disadvantages:

– low radiopacity;
– insufficient adaptation to the walls of root canal;
– possible solubility in a root canal (require careful monitoring of the dryness of canal).

Materials are produced in the form of "paste/paste" system. In addition to calcium hydroxide, they may include non-steroidal anti-inflammatory agents and radiopaque additives. The hardening time in root canal is from 16 to 24 hours depending on moisture. The materials of the third group should be used in combination with gutta-percha pins only.

Materials of the third group include "SealApex", "Apexit" (based on calcium hydroxide), "Phosphadent" (based on calcium phosphate).

Glass-ionomer cements

Glass-ionomer cements have chemical adhesion to dentine, so they are able to qualitatively seal the root canal for a long time.

Advantages of glass-ionomer root sealants:

– high biocompatibility;

– chemical adhesion to dentin;
– strength;
– antimicrobial effect due to fluoride;
– high radiopacity;
– undemanding to dryness of root canal.

Glass-ionomer endosealants are characterized by a long time of solidification (1.5–3 hours), radiopacity and increased biocapacity compared to glass ionomer cements used for filling cavities.

However, these materials are extremely difficult to remove from the root canal after hardening, so they are recommended to be used with gutta-percha only.

This group includes the cements "Ketac – Endo" ("ESPE"), "Endion" ("VOCO"), "Endo-Jen" ("Jen- Dental"), "Endoseal" ("Promedica").

Solid materials (fillers)

Fillers are endodontic filling materials used to fill the root canal. They create vol- ume of the root filling, reduce its shrinkage. They are used only with plastic harden- ing materials (sealers). Fillers include different pins of gutta-percha, silver, titanium, plastic. Most often, as a solid filler of root canal (filler), gutta-percha is used (from the Malay *getah* is gum, resin and *pertja* is a tree that secretes this resin).

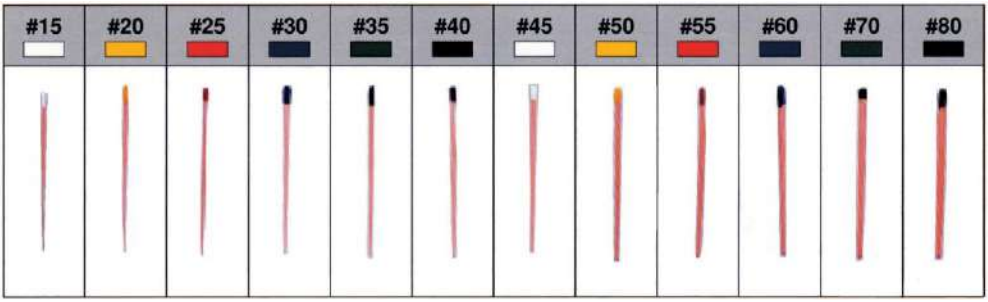
Gutta-percha is a coagulated and specially treated latex obtained from juice of the Brazilian tree Manilkara bidentata and Malaysian trees of the same group. It exists in two crystalline forms (α and β) and in an amorphous melted form (Fig. 8.37):

– α – is sticky and fluid mass, which softens at a relatively low temperature;
– β is more flexible, elastic form, which is used for the manufacture of pins. When heated above 65 ^{0}C, the natural α is a crystalline form becomes amor-

phous and melts. During its slow cooling (0.5 ^{0}C per hour) crystallization β oc- curs, α crystallization occurs at normal cooling rate. β-gutta-percha is used for the manufacture of gutta-percha pins. It has good flexibility, plasticity, low stick- iness and relatively high melting point (64 ^{0}C).

Gutta-percha has been used as a filling material for root canals of teeth for about 100 years. The material tends to expand under influence of heat and shrink after cooling, so when filling root canal it is necessary to create an excessive vol- ume of gutta-percha in it by pressure (condensation).

Composition of the mass for manufacture of gutta-percha pins:
– gutta-percha (about 20 %) – provides the stability of shape, volume and elasticity of a pin;
– zinc oxide (60–75 %) serves as a filler;



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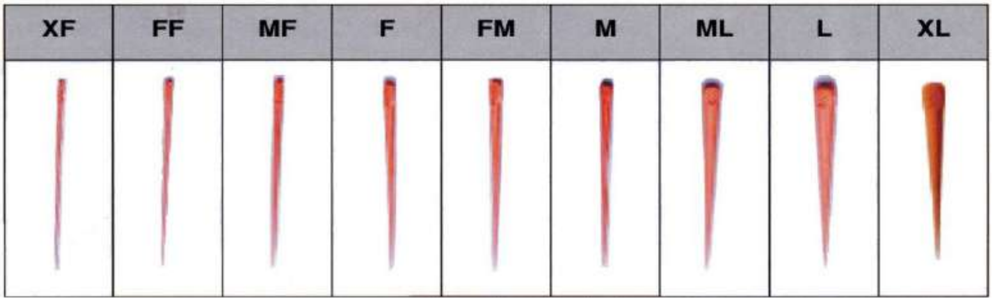

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Fig. 8.37. *Gutta-percha pins and cones*

– wax and (or) resin (1–4 %) provides pliability and possibility of good con- densation;
– metal sulphates (1,5–17,3 %) provide radiopacity;
– biological dyes and substances that prevent oxidation.

Pins for obturation of root canals are made of gutta-percha. Standard pins (corresponding to ISO standard sizes) are marked with corresponding numbers (15, 20, 25, 30, etc.) and color coding (white, yellow, red, blue, etc.).

Non-standard pins are gutta-percha cones of different sizes, with a thicker base, with marked conical shape and sharpened tip, they are indicated with letters in accordance with the thickness (XXF, XF, F, M, L).

Positive properties of gutta-percha pins as a material for permanent root canal obturation:

– plasticity;
– chemical and biological inertness;
– no irritating effect;
– radiopacity;
– shape stability and no shrinkage;
– ensuring long-term and reliable root canal obturation.

Silver pins have been used as root canal filler for over 50 years. Negative prop- erties that prevent their widespread use are: corrosion in liquid media with for- mation of silver oxides, toxic to cells and tissues; change of tooth color after obtu- ration; inability to adapt to root canal shape due to hard rounded tip, which can not repeat the anatomy of root apex, a circular section that is almost never found in natural canals. Silver pins are rarely used in small channels with a round shape of the section. They are radiopaque and easily sterilized.

Materials for filling of root canals in primary teeth and the technique of their use

Zinc-oxide eugenol and iodoform pastes most frequently used for filling of root canals in primary teeth. Studies have been conducted on the relative use of calcium hydroxide-based materials.

Zinc oxide eugenol (ZOE) paste is prepared ex tempore (Zinc oxide + euge- nol (clove oil) + radiopaque substances). Iodoform or thymol as antiseptics are sometimes added to this mass. Root canals are filled with a liquid fraction using machine canal filler (paste is applied to the tool, entered into root canal, pasta is pumped into it during rotation of the tool at low speed and removed from root ca- nal when it continues to rotate). Tightly mixed Zinc oxide eugenol paste is applied and pressed down with a tight cotton ball on the orifices of canals and bottom of tooth cavity in the bifurcation area of a temporary molar. (Fig. 8.38). To fill wide channels in the frontal teeth, a channel filler is used, and a paper pin is used to condense the material.

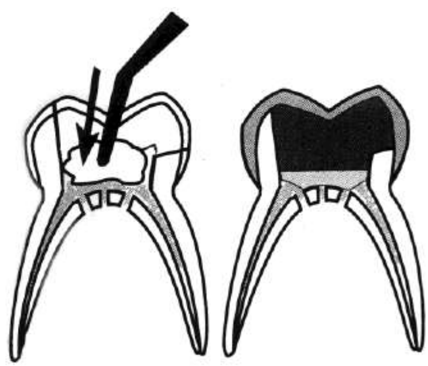
Advantages of Zinc oxide eugenol material for temporary teeth filling:

– possibility of high-quality obturation;
– good marginal fit;
– antiseptic action.

Disadvantages:

– possibility of an irritating effect of eugenol on periodontal tissue;
– slow resorption (does not coincide with the rate of root resorption).

Sometimes after excessive removal of the paste beyond apical foramen, it can persist in alveolar bone for a long time even after resorption of the roots of tem- porary tooth.



with Zinc oxide eugenol paste

Pastes based on Iodoform usually contain iodoform, camphor, parachlorophenol (or thymol, creosote), sometimes – radiopaque additives.

Advantages of iodoform pastes:

– strong antiseptic effect;
– low toxicity;
– reduction of exudation in the periapical tissues.

Disadvantages:

– short time of antiseptic action;
– possibility of allergic reactions;
– loose channel filling;
– rapid resorption.

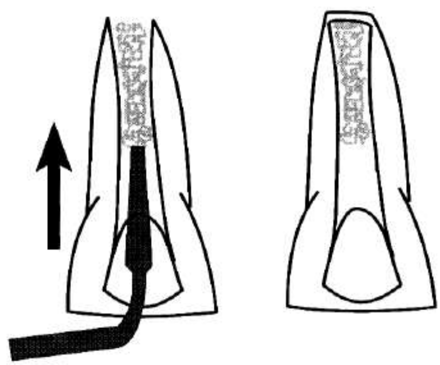
These pastes are inserted into root canal in the same way as Zinc oxide eugenol paste – with the channel filler.

Technique of temporary root canal obturation in permanent teeth with unformed roots

During the endodontic treatment of permanent teeth with incomplete root formation, one of the main tasks is to ensure the possibility of completing of their formation. Therefore, while maintaining the viability of root pulp, pulpotomy technique for treating of pulpitis with further coating of the pulp stump with a non-hardening or hardening drug, containing calcium hydroxide, is recommended.

In the case of root pulp death, after chemomechanical treatment of root canal, it is filled with non-hardening paste based on Calcium hydroxide from a syringe or with canal filler (with pre-fixed working tooth length). A paste in the channel can be condensed with plugger or pin. The insulating material (sterile cotton ball, Zinc oxide eugenol paste) (Fig. 8.39, *a*) is applied to the orifice of channel.

If the top of root is not formed, it is recommended to apply and condense the first portion of paste manually. To do this, a small portion of paste is added to the prepared root canal at the tip of K-file, K-reamer or smooth broash (with pre-fixed working length of tooth) and pushed forward to the unformed apex. Then it is condensed with a pin. The following portions of paste



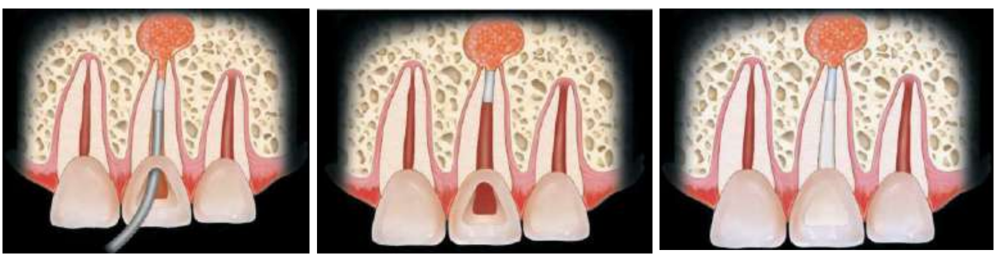
a *b*

Fig. 8.39. Filling of permanent tooth canal with incomplete root formation with the paste based on calcium hydroxide (explanation in the text)

are introduced into root canal with canal-fillers. This technique is due to the fact that in presence of wide apical opening, there is a threat of an excessive removal of filling material into periapical tissues. It can lead o development of complications of endodontic treatment. After a certain period after the temporary obturation of root channel (on average 3–6 months), X-ray control is carried out to find out the presence of a dense bridge in an apical part of root.

If there is one, check its strength with file 35 (you can also use a gutta-percha pin): if instrument penetrates the bridge easily, Calcium hydroxide should be re-injected. If the bridge is not detected on X-ray, refilling of a channel with Calcium hydroxide paste and repeated examination after 3 months are carried out. The formation of a dense bridge, as a rule, occurs within one year (Fig. 8.39, *b*). After its formation and strengthening, a permanent obturation of root canal is carried out. Positive result of endodontic treatment of a permanent tooth with incomplete formation of apex is either the completion of its normal development (apexogenesis), or formation of a dense barrier at the top of root, which is called apexification. The barrier may be osteodentin, cellular or cell-free cement, bone, or osteoid material.

If apexification does not occur, the apical zone can be filled with a material based on mineral trioxidehydrate (for example, "ProRoot", "Trioxident", "Restapex"). Mineral trioxidehydrate (MTA) is biocompatible sterile cement based on calcium oxide, which is mixed in water, hardens in a humid environment and stimulates the formation of hard tissue (protein, cement, bone). Cement powder is mixed on a glass plate with distilled water to pasty consistency and introduced into the apical part of a root canal with special syringe. In the absence of special device, the drug can be injected into the channel using channel-filler, and then tightly condensed with plugger. Remove residues from the walls of canal with (Fig. 8.40, *a*). Then, a wet cotton turunda is introduced into the inner part of root canal, since the material hardens in wet environment; the endodontic access is closed with bandage made of material for temporary filling (Fig. 8.40, *b*). In a



a *b* *c*

Fig. 8.40. *Application of MTA: a – introduction of the material into apical zone of root canal, b – temporary closure of endodontic access,*

c – permanent obturation of root canal few hours, the MTA will harden, forming dense barrier in the area of unfomated root apex. This makes it possible to conduct permanent obturation of the channel (Fig. 8.40, *c*).

Technique of permanent root canal obturation in permanent teeth in children

The permanent obturation of root canals in permanent teeth in children is carried out only after the completion of root formation (closure of the apical opening) or formation of the barrier in root apex zone after apexifixation, provides a relative closure of the tooth cavity.

Before obturation of a root canal, it is advisable to remove the smear layer of dentine, formed as a result of dissection, from its walls. The procedure can be carried out by washing the channel with EDTA and sodium hypochlorite solutions. Before obturation, the channel must be washed with distilled water and dried.

Root canal obturation methods

1. Obturation with a single paste.
2. Obturation with cold gutta-percha pins:
   a) single pin technique;
   b) lateral condensation of gutta-percha and its varieties.
3. Obturation of heated gutta-percha (vertical condensation of gutta-percha).
4. Obturation of thermoplastic gutta-percha:
   a) syringe injection or application of other similar systems;
   b) solid-core application (application of systems such as Thermafil and Soft-Core).

Obturation of canals with heated gutta-percha provides heating of gutta-percha directly in a root canal. During obturation of thermoplastic gutta-percha, it is heated before entering a channel.

Method of root canal obturation with one paste

The method is simple, quickly carried out with channel filler. However, there is high risk of excessive filling of channel and removal of filling material behind the top of root, the root filling can be porous, has high shrinkage, there is dan- ger of washing out of paste at the channel, the resorption of material in it. This method can be applied when filling the root canal with Zinc-oxide eugenol paste. This method is not recommended for permanent root filling in permanent teeth, because it does not guarantee reliable obturation of the root canal.

The method of root canal obturation with one paste is used for temporary obturation in order to fill it with treatment pastes. Filling of canals with paste can be carried out both manually, and by means of a channel filler.

Technique of root canal filling with paste using a channel filler:

1) select the canal filler of appropriate size (slightly smaller than size of the last tool that was used to expand a channel);
2) canal filler is fixed in handpiece and stopper disc is used to mark the working length. The working part of canal filler is dipped into a filling material so that a small amount of material remains on it;
3) canal filler is gently inserted into a root canal along the working length so that it can move freely in the channel without jamming. The drill machine is turned on at low speeds for 2–3 s. After that, without turning off the drill machine, rotating canal filler is slowly removed from canal and the handpiece is turned off;
4) canal filler is again dipped in a filling material and inserted into root canal along 2/3 of the working length. Filling material is pumped in the same sequence;
5) procedure is repeated again, entering canal filler only along 1/3 of the working length;
6) filling material is condensed with a cotton ball at the orifice of root canal;
7) X-ray quality control of root canal filling is carried out.

If the apical foramen is wide, for example, in teeth with unformed roots, the first portion of paste is recommended to be introduced into root canal manually, and only after that, a canal filler is used. This is necessary to prevent the removal of a paste excess into the periapical tissues and development of possible complications.

Single pin method

The essence of method is that into a root canal one pin is inserted, together with the hardening paste (sealer). It condenses filling material, evenly distributes it in the canal, obturates an apical foramen. The method can be used if the walls of canal are relatively parallel, and the main pin tightly enters an apical third of root channel.

The advantages of this method are: ease of implementation and better sealing of the root filling compared to filling with paste only.

The disadvantages – complexity of achieving of a dense obturation (only the macrochannel is obturated) and its unreliability, since between pin and walls of root canal, there is a sufficiently thick layer of paste, which can dissolve over time. The single-pin method can be applied if the canal cross-section is circular.

Stages of root canal filling by single pin method

1. *Selection and fitting of the pin.* Take gutta-percha pin of the same size as the last endodontic instrument, which was used to process an apical part of canal (Master-file). The pin is inserted into root canal along the working length. Tip of the pin should be slightly wedged in root canal in the area of apex. A mark, fixing the working length, is made on the pin. In doubtful cases, X-ray control of the placement of pin in a channel is carried out.
2. *Placement of endosealer in the channel.* Paste is inserted into root channel by K-file, K-reamer or channel filler to the level of apical foramen. It is not recommended to fill canal tightly in order to avoid removal of a filling ma- terial behind the apical foramen.
3. *Preparing a channel for the pin.* Manipulation is carried out in order to facilitate placement of the pin into root canal. To do this, K-reamer of a smaller diameter than in the selected pin is slowly insertsd into root channel to the top and just and slowly withdrawn.
4. *Insertion of the pin into root canal.* The pin is covered with a filling material and inserted into root canal along a working length. Movement of the pin hould be slow to expel air from root canal. For the same purpose, it is rec- ommended to carry out several progressive and rotational movements in it. The excess of filling material, which came out of channel, is removed with an excavator or a cotton ball.
5. *Removal of excess part of the pin* protruding from a root canal is carried out with a heated carver.
6. *X-ray quality control of filling*.

Lateral condensation method of cold gutta-percha

The method of lateral condensation of gutta-percha consists in dense filling of root canal with gutta-percha pins together with hardening paste (sealer). This leads to reliable obturation of apical foramen, full filling of the entire root canal, ensures tight fit of the root filling to walls of root canal.

Sequence of manipulations

1. *Determining size of the first (main) pin (Master point).* The size of pin should correspond to the size of last tool with which the apical part of a channel was processed (Master-file). When fitting the pin in a canal, it should be placed so that it does not reach the physiological tip by 1 mm. This is nec- essary in order to avoid the removal of pin into periapical tissues during condensation of gutta-percha. X-ray control is carried out to check the cor- rectness of fitting. After fitting the main pin, mark is made on it, fixing the length by which it should be insertsd into root canal.

2. *Selection of the spreader*. The spreader (side seal) is selected, it is of the same size as Master-file or one size larger, so as not to go beyond the apical fora- men (Fig. 8.41, *a*). The working length of spreader should be 1–2 mm short- er than the working length of a channel. The main pin is removed from channel after its fitting.
3. *Washing and drying* of root canal with paper pins.
4. *Introduction of endosealant to canal*. Sealer is introduced into root canal using K-file, K-reamer or canal filler to the level of an apical foramen and is evenly distributed along the walls of root canal by rotating the tools counter clockwise. A channel should not be filled tightly.
5. *Placement of the main pin to a canal*. The main pin, lubricated with sealer, is slowly introduced into root canal along the working length (Fig. 8.41, *b*). To expel the excess air, several reciprocating movements of the pin are carried out in a canal.
6. *Lateral condensation of gutta-percha*. In a root canal the spreader is insert- ed by 1–2 mm less than working length, with movements that resemble winding of watches. The spreader is left in a canal for 30–60 s (during this time gutta-percha pin deforms and adapts to the walls of root canal). Then or about 1 min, rotary-vertical movements are performed clockwise and counter clockwise to make space for an additional pin (Fig. 8.41, *c*).

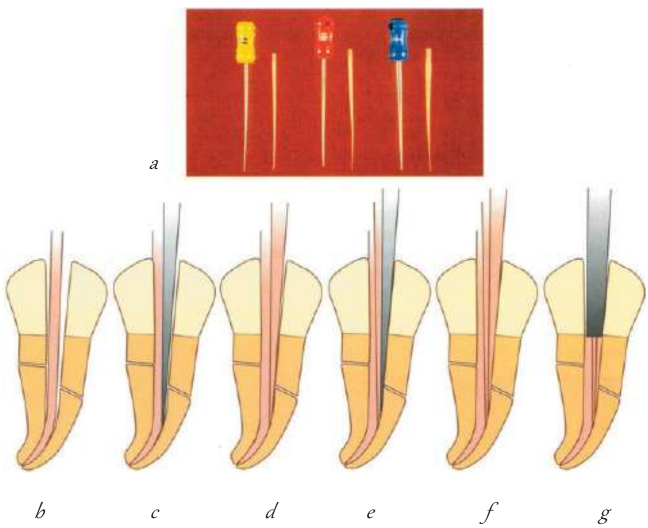


Fig. 8.41. Lateral condensation of gutta-percha: *a* – finger spreaders of three sizes (very thin (Fine Fine), medium (Medium Fine) and thin (Fine)) with gutta-percha pins of the corresponding size; *b* – Master-pin in a root canal; *c* – condensation of the Master-pin; *d* – an additional pin inserted into the space created by spreader during condensation; *e*–*g* – condensation of the first additional pin, introduction of another pin and the final stage of filling

7. *Removal of the spreader and introduction of an additional pin*. The spreader is slowly removed from a root canal by rotational movements and between the main pin and the wall of root canal, an additional pin is immediately introduced, lubricated with a sealer (Fig. 8.41, *d*). The additional pin is se- lected of the same size as the spreader or one size smaller.
8. Lateral condensation of gutta-percha, removal of the spreader and *introduction of a second additional pin*. The spreader is introduced into root canal by 1–2 mm less than at the previous stage. Work with spreader is repeated (Fig. 8.41, *e*), the following additional pin is introduced (Fig. 8.41, *f*), etc. The size of additional pin usually corresponds to the size of spreader, which was used for condensation immediately before its place- ment. The size of spreader is gradually reduced. Non-standard pins can be used as additional, although the choice depends mainly on shape and de- gree of taper of root channel. Obturation is considered to be complete if spreader cannot enter a channel.
9. *Removal of excess gutta-percha and paste*. Protruding from orifices of root canal, the ends of pins are cut with a heated tool to the level of orifices (Fig. 8.41, *g*). The procedure is completed by vertical condensation of gut- ta-percha at orifice with a large plugger.
10. *X-ray quality control of root canal filling*.

During the lateral condensation gutta-percha pins look like immured in a solid mass of the endosealant, filling all gaps between them. The apical foramen should be obturated with only one pin, tightly adjacent to walls of root channel in the area of physiological apical narrowing.

Features of the cold condensation technique of gutta-percha in permanent teeth with unformed roots

The technique of gutta-percha obturation of wide (tubular) canals with thin walls after apexification involves use of very large primary pins, gutta-percha cones or specially prepared pins (made of several thick heated pins by digging out with a spatula or two pieces of glass followed by spraying with chloroethyl or ice water to harden).

The technique of “inverted pin” can also be used for obturation of such wide canals by lateral condensation technique. Large gutta-percha pin or cone is used as the main pin (Master-pin), which is inverted in order to obturate a wide apical hole in permanent tooth with unformed root with its thick end. Then, X-ray examination of its location in the apical zone of root is carried out (Fig. 8.42). The filling is carried out using sealers and additional pins according to the method described above.

To fill the apical funnel of root, the Master-pin is sometimes modified by heating or chemical plasticizing of its tip with a special sol- vent.When the pin is inserted into channel, the softened gutta-percha is distributed under pres- sure in a wide apical section of root canal, filling it more efficiently than a cold solid pin.

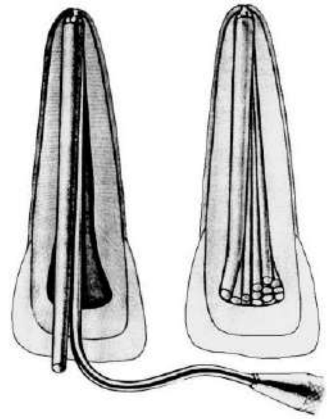


Fig. 8.42. *Obturation of tubular root canal using "inverted pin" technique*

Vertical condensation of the heated gutta-percha

Herbert Shilder proposed the technique of vertical condensation of heated gutta-percha in 1967. It provides a maximum filling of root canal with the gutta-percha with a minimum amount of sealer.

Stages of canal obturation:

1. Drying of the canal with a paper pin.
2. Fitting of the pin and cutting of it to a thick end (Fig. 8.43, *a*, *b*).
3. Removing the pin and cutting 0.5–1.0 mm of the top. Replacement and retention check.
4. Selection of pluggers: the first should enter a canal at the distance of 15 mm from a top, the second – 10 mm, the last – 3–4 mm. Denoting the working length of each plugger (Fig. 8.43, *c–e*).
5. Irrigation and drying of the canal.
6. Placement of a small amount of sealer with a needle (file, manual canal filler) and easy coating of the walls with it (sealer is necessary when filling heated gutta-percha, in particular, to compensate for its shrinkage during cooling).
7. Coating apical third of the pin with a thin layer of sealer.
8. Placement of a pin, fixing its length (Fig. 8.43, *f*).
9. Removal of excess pin in orifice of root canal by means of a hot excavator or a heating plugger (thus the first warm wave is created, which increases the temperature of gutta-percha by 5–8 ^{0}C and leads to its deformation during condensation) (Fig. 8.43, *g*).
10. Beginning of condensation: the largest plugger is lowered into cement powder and then gutta-percha is condensed in the apical direction (at this time there is an obturation of lateral channels in the middle third of root channel) (Fig. 8.43, *h*).

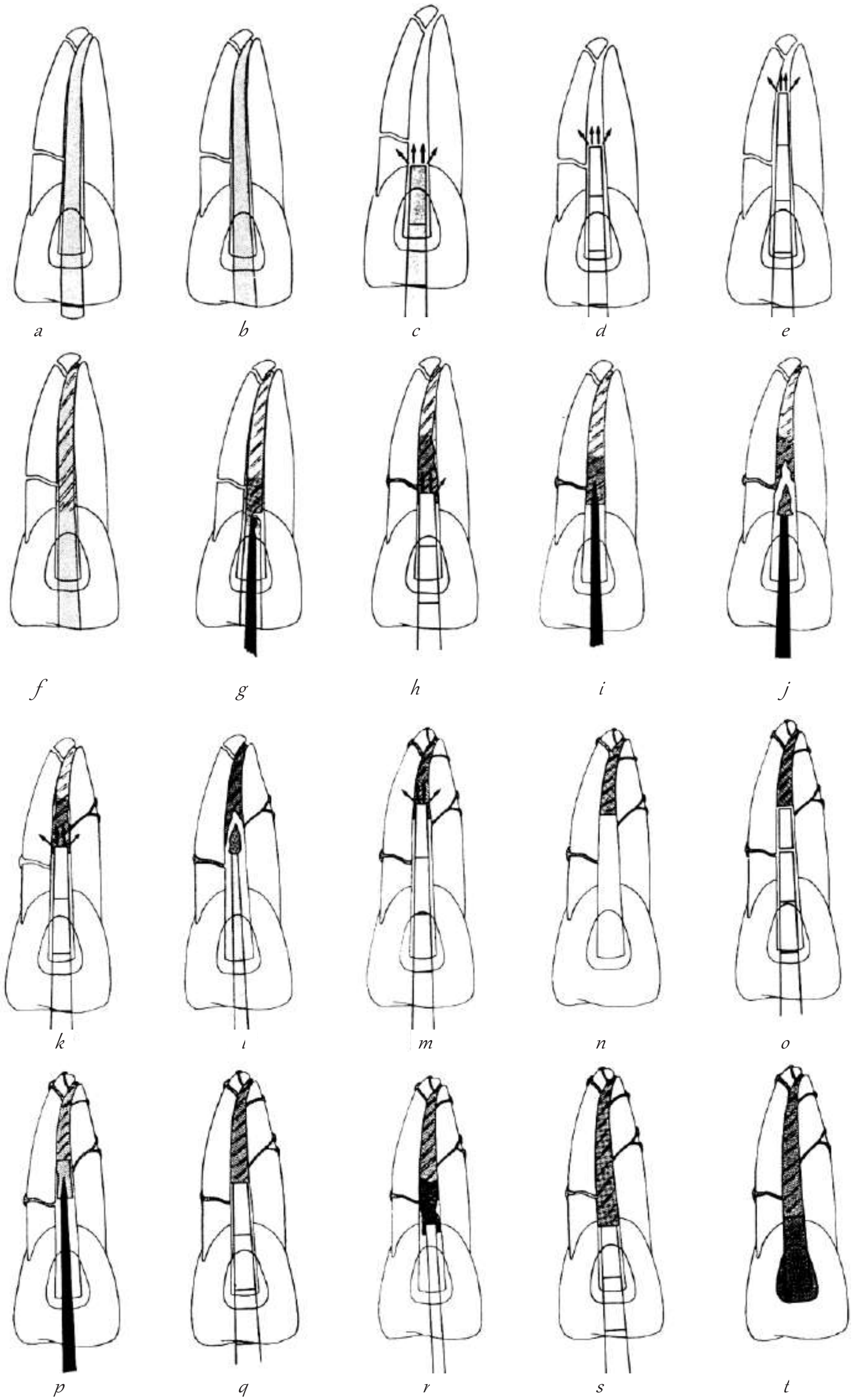


Fig. 8.43. *Obturation of a root canal using the technique of vertical condensation of hot gutta-percha (explanations in the*

text)

11. Creating a second heat wave by immersing the hot pointed part of the heating plugger or spreader in the channel for 2–3 seconds (Fig. 8.43, *k–m*).
12. Vertical and lateral condensation by a medium-sized plugger (at this time, lateral channels continue to get filled). Condensation at a distance of 3–4 mm from the top (Fig. 8.43, *n*).
13. The second heating with a heating plugger or spreader (Fig. 8.43, *o*).
14. Vertical condensation by the thinnest plugger (Fig. 8.43, *p*).
15. Completion of the apical filling (removal of gutta-percha residues from the walls with a plugger) (Fig. 8.43, *q*).
16. Backpacking is the filling of canal with cut gutta-percha fragments, their cold condensation by plugger, heating, condensation and further repetition of these actions to the final filling of channel. At this stage, it is also possible to inject gutta-percha with a syringe or fill the remaining space by lateral condensation of gutta-percha (Fig. 8.43, *r–f*).
17. Cleaning of a tooth cavity to enamel-dentin junction, its temporary restoration. Cement is sometimes added in the precervical area of a molar (sealing of bifurcation).

The method can be used in permanent teeth with tubular channels after apexification, but it is necessary to control the force of pressure to avoid the destruction of created apical barrier.

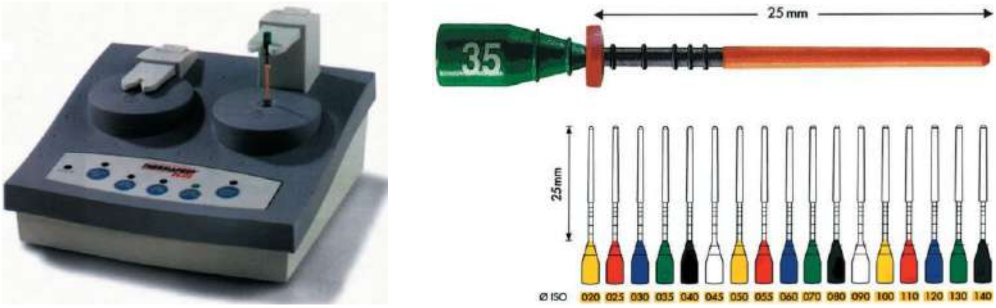
Obturation by injection of thermoplasticized gutta-percha

The method of obturation by injection of thermoplasticized gutta-percha consists in the placement of heated gutta-percha from a syringe heated to 160 ^{0}C (temperature of material passing through a needle) into the channel.

Currently, Obtura II Heated Hutta-Percha System (Unitek) with temperature levels from 160 to 200 ^{0}C, Ultrafil (Hygienic) are used to perform this method. In wide channels, the method gives good results with significant time savings.

Canal obturation using Thermafil system

The method of canal obturation using Thermafil system was developed by Johnson B. W. in 1978. It provides obturation of root canal with gutta-percha alfa-phase applied to steel, nickel-titanium or plastic material (obturator). Before placement the obturator is heated in a special heating device, and sealer is introduced into the channel (Fig. 8.44, *a*). Then the heated obturator (Fig. 8.44, *b*) is inserted into a root canal along the entire working length with small pressure towards an apical foramen. Molten gutta-percha and endosealant tightly obturate a canal and come in side branching. As a result, there is full three-dimensional



a *b*

Fig. 8.44. Thermafil: *a* — oven for heating of gutta-percha on the obturator; *b* — obturator

obturation of the entire root canal. The method provides sufficient obturation of wide canal of child’s tooth after apexification, accurate apical control and good tactile feedback when filling the canal.

Upon completion of the canal obturation, endodontic access is closed with glass-ionomer cement and the final restoration of tooth is carried out, often with use of artificial crowns or pin structures.

Algorithm of disclosure a primary or permanent tooth cavity

Material supply:

- dental unit;
- dental handpieces (turbine, mechanical);
- diamond heads: spherical, cylindrical with safe tip for turbine handpiece;
- carbide burs: spherical and cylindrical for mechanical handpiece;
- carbide endodrills with a safe tip;
- drill Gates-Glidden, reamer Peeso (Largo) for expansion of a root canals orifices;
- kit of dental instruments (probe, mirror, tweezers, excavator, metal spatula, plugger-curver).
- cotton rolls.

Algorithm to perform dental procedures

№	Action sequence	Criteria for control of correct execution
1	If necessary, anesthetize the tooth	Tooth is insensitive to action of temperature stimuli. Painless probing of the bottom of carious cavity
2	Carry out necrectomy of carious cavity by means of turbine and mechanical handpieces with spherical	The overhanging edges of enamel are removed. Dentin surface on bottom and walls of carious cavity has
3	Carry out antiseptic treatment of carious cavity	Carious cavity is clean, does not contain dentin sawdust
4	Dry carious cavity with air gun, directing it at the walls	Carious cavity is dry
5	In absence of connection of the carious cavity with pulp chamber, open the tooth cavity at one point (in horn projection) with turbine or mechanical handpiece and	When probing, the connection of carious cavity with tooth cavity at one point is determined
6	Remove roof of the tooth cavity with turbine or mechanical handpiece with spherical or cylindrical diamond heads and burs, endoburs with a safe tip. Fully	Roof of the tooth cavity is missing. Walls of carious cavity vertically (without ledges) pass into the walls of tooth cavity
7	In presence of pulp in the tooth cavity, isolate it from saliva and carry out amputation (removal) of crown pulp with a sharp excavator or a mechanical handpiece with a	Tooth is not in contact with saliva. There is no crown pulp. Bottom of tooth cavity and orifices of root canals are fully accessible for visual inspection. There is a visible

8	In permanent teeth with formed roots, expand the orifices of root canals using spherical burs with an elongated working part (27 mm) or tools with a safe	In formed permanent teeth the orifices of root canals are expanded
Note. At the next stage, in presence of pulp in root canal, its extirpation is carried out, and in absence – instrumental and		

Algorithm of instrumental treatment of primary tooth root canal according to the standard technique

Material supply:

- dental unit;
- kit of dental instruments (probe, mirror, tweezers, excavator, metal spatula, plugger-curver);
- kit of endodontic instruments of different sizes: root needles, K-reamers, K- and H-files;
- endodontic syringe with needles;
- adsorption paper pins of different sizes;
- means for antiseptic treatment of root canal (0.5–1.0% solution of sodium hypochlorite; 0.05% solution of chlorhexidine);
- slide glass plates;
- cotton rolls.

Algorithm to perform dental procedures

№	Action sequence	Criteria for control of correct execution
1	Determine the working length of tooth using X-ray method. For a temporary tooth it should be 2-3 mm	The working length of tooth is fixed on an endodontic instrument with silicone stopper
2	Isolate a tooth from saliva with cotton rolls, apply a	Tooth is not in contact with saliva
3	Carry out antiseptic treatment of carious cavity and tooth	Carious cavity and tooth cavity are clean
4	Pass root canal for the entire working length with K-reamer of the appropriate diameter (one size smaller than	K-reamer of the appropriate size is inserted into a root canal along the entire working length of tooth
5	Carry out antiseptic treatment of root canal by washing it with an endodontic syringe with a needle or a paper	Root channel is moistened with an antiseptic solution

6	Expand root canal by 2-3 sizes by removing predentine from its walls with K- and H-files, gradually increasing their diameter. To do this, insert the endodontic instrument into a root canal along the entire working length. It is necessary to carry out vertical, cutting movements along perimeter of root canal, tightly pressing it against the wall. After	Endodontic instrument (minimum size 25) passes root canal along the entire working length. Softened predentine is completely removed. The walls of root canal are dense. Dentin chips, which remain on file, have a light color
7	Carry out antiseptic treatment of a root canal after	Paper pin after removal from root canal is clean
8	Dry root canal with absorption paper pins of	Paper pin is dry and clean after removal from root
Note. The next step is a temporary or permanent obturation of a root canal.		

Algorithm of instrumental treatment of root canal of a permanent tooth with incomplete root formation according to the standard technique

Material supply:

- dental unit;
- kit of dental instruments (probe, mirror, tweezers, excavator, metal spatula, plugger-curver);
- kit of endodontic instruments of different sizes: root needles, K-reamers, K- and H-files;
- endodontic syringe with needles;
- adsorption paper pins of different sizes;
- antiseptics for treatment of root canal (0.5 to 1.0 % solution of sodium hypochlorite; 0.05 % solution of chlorhexidine);
- slide glass plates;
- cotton rolls.

Algorithm to perform dental procedures

№	Action sequence	Criteria for control of correct execution
1	Determine the working length of a tooth using X-ray method. For an unformed permanent tooth, it should be 1.5-2 mm shorter than its radiological length	The working length of a tooth is fixed on endodontic instrument with silicone stopper
2	Isolate a tooth from saliva with cotton rolls, apply	Tooth is not in contact with saliva

3	Carry out antiseptic treatment of carious cavity and tooth	Carious cavity and tooth cavity are clean
4	Pass root canal along the entire working length with K-reamer of the appropriate diameter (one size smaller than the diameter of root canal) with safe (non-aggressive)	K-reamer of the appropriate size is inserted into root canal along the entire working length of tooth
5	Perform antiseptic treatment of root canal by gently washing it with an endodontic syringe with a needle or a paper pin moistened with antiseptic	Channel is moistened with an antiseptic solution
6	Remove infected predentine from the walls of root canal using K- and H-files of appropriate size with safe (non-aggressive) tip. To do this, insert the endodontic instrument into root canal along the entire working length. It is necessary to carry out vertical, cutting movements along the perimeter of root canal, tightly	Endodontic instrument (minimum size 25) passes root canal along the entire working length. The softened predentine is completely removed. Walls of root canal are dense. Dentin chips, remaining on file, have a light color
7	Perform antiseptic treatment of root canal after each	Paper pin after removal from root canal is clean
8	Dry root canal with absorption paper pin of	Paper pin are dry and clean after removal from root
Note. At the next stage, temporary or permanent obturation of root canal is carried out.		

Algorithm of temporary obturation with Calcium hydroxide paste of a permanent tooth with unformed roots

Material supply:

– dental unit;
– mechanical handpiece with regulation of rotation speed;
– kit of dental instruments (probe, mirror, tweezers, excavator, metal spatula, plugger-curver).
– kit of endodontic instruments of different sizes: smooth broashes, K-reamers, K- and H-files,canal fillers;
– endodontic syringe with needles;
– adsorption paper pins of different sizes;
– antiseptics for root canal treatment (0.5-1.0 % sodium hypochlorite solution; 0.05 % chlorhexidine solution);
– slide glass and paper plates;
– cotton rolls;
– calcium hydroxide-based materials for long-term root canal obturation: “Calcium hydroxide” (Septodent), “Calcicur” (VOCO), “Calxyl Blau”(VOCO).

Algorithm to perform dental procedures

№	Action sequence	Criteria for control of correct execution
1	Isolate tooth from saliva with cotton rolls, apply a saliva	Tooth is not in contact with saliva
2	Perform antiseptic treatment of root canal	Paper pin is clean after removal from root canal
3	Dry root canal using adsorption paper pins with vertical	Paper pins are dry and clean after removal from
4	Apply the required amount of Calcium hydroxide- containing paste to slide glass or paper plate for temporary obturation of	Paste is prepared immediately before filling to prevent its inactivation when interacting with air
5	Fix the working length of a tooth on the canal filler with silicone stopper. For an unformed permanent tooth, it should be 1.5-2 mm shorter than its radiological length	Stopper is fixed at the level of working tooth length
6	Draw up a small amount of filling material on canal filler of appropriate size and insert it into root canal. Turn on handpiece at low speed and move the working canal filler further into canal along the working length of tooth. Carry out several pumping movements with canal filler in the vertical direction. At the end of manipulation, slowly remove canal filler from root canal at the turned on rotations in order to avoid the formation of	Canal filler is inserted into root canal in compliance with the working length of tooth. Filling material tightly fills the orifice of root canal
7	Apply temporary filling. Prepare temporary filling material according to the procedure, insert it into carious cavity and	Carious cavity is completely filled with temporary filling material, tightly adjacent to its
Note. Before applying temporary filling, X-ray control of the quality of temporary root canal obturation should be performed		

Algorithm of permanent obturation with Zinc oxide eugenol (ZOE) pasta of root canal in primary tooth

Material supply:

– dental unit;
– mechanical dental handpiece with regulation of rotation speed;
– kit of dental instruments (probe, mirror, forceps, excavator, metal spatula, plugger-curver);
– kit of endodontic instruments of different sizes: smooth broashes, K-reamers, K- and H-files, channel fillers;
– endodontic syringe with needles;

– adsorption paper pins of different sizes;
– antiseptics for root canal treatment (0.5-1.0 % sodium hypochlorite solution; 0.05 % chlorhexidine solution);
– slide glass plates;
– cotton rolls;
– zinc oxide powder and eugenol for preparation of the filling paste ex tempore.

Algorithm to perform dental procedures

№	Action sequence	Criteria for control of correct execution
1	Isolate a tooth from saliva with cotton rolls, apply saliva	Tooth is not in contact with saliva
2	Perform antiseptic treatment of a root canal	Paper pins are clean after removal from root
3	Dry root canal using adsorption paper pins with vertical	Adsorption paper pin is dry and clean after
4	Apply required amount of liquid drops to slide plate (according to the instruction). Bottle of liquid should be held high so that	Compliance with the optimal ratio of powder and liquid (average 3: 1)
5	Before pouring the powder, shake bottle several times. Measure the required amount of powder with measuring spoon included in material set (according to the instruction). Pour the powder	Compliance with the optimal ratio of powder and liquid (average 3: 1)
6	Measured amount of powder should be added to the liquid in small portions. Use metal spatula to mix for 1-2 minutes	Compliance with the mixing time. Mass is homogeneous, does not reach for spatula, but comes off, forming ridges of several millimeters
7	Fix the working length of a tooth on canal filler with silicone stopper. For a temporary tooth it should be 2-3 mm shorter	Stopper is fixed at the level of working length of tooth
8	Draw up a small amount of filling material on canal filler of appropriate size and insert it into root canal. Turn on handpiece at a low speed and move the working canal filler further into canal along the working length of tooth. Implement several pumping movements with it in the vertical direction. At the end of manipulation, slowly remove canal filler from root canal at the turned on rotations in order to avoid the	Canal filler is inserted into root canal in compliance with the working length of a tooth. Filling material tightly fills the orifice of root canal
9	Add powder to the prepared paste and mix it more tightly. Apply paste on the orifices and bifurcation area in a molar	Area of bifurcation in a molar and orifices of root canals are filled with Zinc oxide eugenol paste of

10	Apply temporary or permanent filling. Prepare temporary filling material according to the procedure, insert it into carious cavity	Carious cavity is completely filled with filling material, tightly adjacent to its edges
Note. Before applying a temporary or permanent filling, perform X-ray quality control of the root canal obturation.		

Algorithm of permanent obturation of a root canal in permanent tooth by lateral condensation of cold gutta-percha

Material supply:

– dental unit;
– mechanical handpiece with a regulation of rotation speed;
– kit of dental instruments (probe, mirror, tweesers, excavator, metal and plastic spatulas, plugger, carver);
– kit of endodontic instruments of different sizes: smooth broashes, K-reamers, K- and H-files, canal fillers;
– endodontic syringe with needles;
– adsorption paper pins of different sizes;
– antiseptis for root canal treatment (0.5–1.0 % sodium hypochlorite solution; 0.05 % chlorhexidine solution);
– slide paper and glass plates;
– cotton rolls;
– filling material for permanent root canal obturation (sealer);
– gutta-percha pins of different sizes.

Algorithm to perform dental procedures

№	Action sequence	Criteria for control of correct execution
1	Determine size of the first (Master-point) pin. It should correspond to the diameter of last tool (Master-file) with which the apical part of root canal was processed. Mark the working length of tooth on the pin. After fitting remove the pin	The main pin enters root canal along the entire working length, it is held at the level of apical foramen. On X-ray, the gutta-percha pin fills channel along the entire working length (not
2	Pick up spreader. Its size should correspond to the diameter of master-file or should be one size larger to prevent it from moving beyond the apical foramen. The working length of	The chosen spreader is the same as or one size larger than the diameter of master-file
3	Isolate tooth from saliva with cotton rolls, apply saliva injector	Tooth is not in contact with saliva

4	Perform antiseptic treatment of root canal	Paper pins are clean after removal from root
5	Dry root canal using adsorption paper pins with vertical	Adsorption paper pin is dry and clean after
6	Prepare sealer (endosealant) according to the instruction	Filling mass is homogeneous
7	Insert sealer (endogermetic) into root canal using K-file, K-reamer or canal filler with the pre-fixed working length of tooth. Evenly distribute it on the walls of channel, carrying out	Sealer is evenly distributed without excess on the walls of root canal
8	Apply sealer to the main pin and slowly insert it into root canal along the entire working length. To expel the excess air to carry out a few reciprocating movements with pin	The main pin is inserted into root canal along the entire working length
9	Carry out lateral condensation of the main pin. Insert spreader into root canal with movements that resemble winding of watches. The depth of introduction of spreader for condensation of the main pin should be 1-2 mm shorter than the working one. Leave spreader in canal for 30 seconds. Perform rotation-vertical movements both clockwise and counter clockwise for about 1 min in order to make space for the	Spreader is inserted into root canal to a depth of 1-2 mm shorter than the working length. At the end of manipulation, spreader enters root canal more freely than before the beginning of condensation
10	Apply sealer to first additional pin, the size of which corresponds to the diameter of previously used spreader or one size smaller. Insert an additional pin into root canal between	First additional pin of appropriate size is inserted into root canal to the depth that is 1-2 mm shorter than the working one
11	Carry out lateral condensation of first additional pin. Enter next spreader into root canal, the diameter of which is one size smaller than the previous one. The depth of introduction of a spreader for condensation of an additional pin should be 1-2 mm shorter, than at the previous stage. Carry out work with	Spreader of appropriate size is inserted into root canal to the depth that is 1-2 mm shorter than at the previous stage
12	Insert additional pins sequentially into the root canal with sealer pre-applied to them. The size of each additional pin should gradually decrease and correspond to the diameter of previously applied spreader. Seal additional pins sequentially with spreaders, the size of which must be gradually reduced. The depth of introduction of each following spreader should be	When the canal is completely obturated, spreader cannot be inserted into the root canal

13	Remove excess gutta-percha and sealer. Cut off the ends of pins protruding from orifice of the root canal with a tool heated over	The ends of gutta-percha pins are determined at the level of orifice of root canal
14	Carry out vertical condensation of gutta-percha in the orifice of	At the orifice of root canal, a densely
15	Apply temporary or permanent filling. Prepare temporary filling material according to the procedure, insert it into carious cavity	The carious cavity is completely filled with a filling material tightly adjacent to its edges
Note. Before applying a filling carry out X-ray quality control of the permanent obturation of root canal.		

Control questions

1. Characterize the structure and purpose of basic types of endodontic instruments.
2. How the disclosure of tooth cavity in primary and permanent teeth of different groups carried out?
3. What techniques and tools should be used in the endodontic treatment of primary teeth?
4. What techniques and tools should be used in the endodontic treatment of permanent teeth with incomplete root formation?
5. What methods of antiseptic treatment of root canals do you know? Name the drugs used for this purpose.
6. Describe the groups of filling materials used for temporary and permanent obturation of root canals. What are their advantages and disadvantages?
7. What materials are used for permanent obturation of root canals of primary teeth? Describe its technique.
8. What is the purpose of temporary root canal obturation in permanent teeth with incomplete root formation? Describe its technique.
9. What materials and techniques are used for permanent obturation of root canals in formed permanent teeth? Describe the technique of lateral condensation of cold gutta-percha.
10. What are the features of permanent filling of root canals of permanent teeth upon completion of apexification of gutta-percha?

Test tasks to the section "Endodontics of primary and permanent teeth in children"

1. **When examining the oral cavity of a 6-year-old child, carious cavity connecting with tooth cavity was revealed on the medial contact surface of 74 tooth. Determine from what surface the disclosure of tooth cavity of 74 should carried out.**

A. Oral B. Occlusal C. Vestibular D. Medial-contact E. Distal- contact.

2. **In a child of 7 years old, dentist conducts endodontic treatment of the second temporary molar of upper jaw. What tools should be used to safely dissect tooth cavity?**

A. Spherical burs B. Cone-shaped burs
C. Cylindrical diamond heads D. Spherical diamond heads
E. Cylindrical endoburs.

3. **The endodontic instrument is designed to pass root canal. It is made of wire of triangular or square section by twisting. The tool can be rotated at 180° in root canal. What is the name of this tool?**

A. K-file B. Smooth broash C. Barbed broash
D. K-reamer E. H-file.

4. **In an 8-year-old child, dentist performs instrumental treatment of unformed root canals of the tooth 16. What tool is appropriate to use to remove infected predentine from walls of canals?**

A. H-file B. Peeso reamer C. Pathfinder
D. Canal filler E. Smooth broash

5. **In a child of 8.5 years old, dentist performs endodontic treatment of the first permanent molar of left half of lower jaw. What method is appropriate to use for instrumental treatment of unformed root canals in this case?**

A. Step-Back B. Crown Down C. Hybrid
D. Standard E. Of balanced forces.

6. **In a 14-year-old child, the dentist performed instrumental treatment of root canal of the 21 tooth. What minimum size is it necessary to expand the apical part of root canal of permanent tooth with formed root?**

A. 15 mm B. 20 mm C. 25 mm D. 30 mm E. 35 mm.

7. **For instrumental treatment of root canals of the 36 tooth in a child of 12 years old, a technique was applied, providing for their passage and expansion from the top to orifice with a gradual increase in size and length of endodontic instruments. Determine the name of this technique of instrumental treatment of root canals.**

A. Step-Back C. Hybrid E. Of balanced forces.
B. Crown Down D. Standard

8. **In a 6-year-old child, dentist performs endodontic treatment of 85 tooth. What material for permanent root canal obturation should be used in this case?**

A. Based on zinc oxide and eugenol C. Based on polymers and resins
B. Based on phenol and formalin D. Based on glass-ionomer cements.

9. **In a child of 8.5 years old, the dentist performs endodontic treatment of the 21 tooth. What filling material should be used for temporary obturation of unformed root canal in this case?**

A. Based on glass-ionomer cements. C. Based on polymers and resins
B. Based on phenol and formalin D. Based on calcium hydroxide.

10. **A 9-year-old child underwent endodontic treatment of the 21 tooth. What method of filling with gutta- percha is advisable to apply for permanent obturation of root canal with an unformed wide apical foramen?**

A. Thermoplasticized gutta-percha C. Inverted pin
B. Heated gutta-percha D. Vertical condensation of gutta-percha.

Answers to the test tasks to the section “Endodontics of temporary and permanent teeth in children”

1 – B 6 – C

2 – E 7 – A

3 – D		8 – A

4 – A		9 – D

5 – D		10 – C

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