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

РЕСТАВРАЦИОННЫЕ МАТЕРИАЛЫ И ТЕХНИКИ. ЭНДОДОНТИЧЕСКОЕ ЛЕЧЕНИЕ

RESTORATIVE MATERIALS AND TECHNIQUES. ENDODONTIC TREATMENT

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

Минск БГМУ 2020

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Подробно рассматриваются классификации, особенности состава, свойства, показания и противопоказания к применению современных материалов для прямой реставрации зубов, дается обоснование выбора реставрационного материала в разных клинических ситуациях, разбираются все этапы и особенности восстановления твердых тканей зубов с использованием современных композиционных материалов, стеклоиономерных цементов, амальгамы. Изложены основные принципы и правила эндодонтического лечения, его этапы, критерии оценки эффективности, возможные ошибки и осложнения, а также врачебная тактика при их возникновении.

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

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RESTORATIVE MATERIALS

MOTIVATIONAL CHARACTERISTIC OF THE THEME

Total time: 70-90 minutes (seminar).

Restorative dental materials are used to prevent or repair teeth lesions caused by oral disease or trauma. An understanding of the physical, chemical and mechanical properties of materials used in dentistry is of tremendous importance. First, materials used to replace missing portions of teeth are exposed to attack by the oral environment and subjected to biting forces. Second, the restorative materials are cleansed and polished by various prophylactic procedures. As a result, their properties are the basis for the selection of materials to be used in particular dental procedures and restorations. A factor significantly contributing to the failure of restorations is the inappropriate use and abuse of dental materials. This problem can be minimized by ensuring a thorough understanding of the composition and chemistry of dental materials and an appreciation of their physical and mechanical properties.

The purpose of the seminar: to integrate knowledge of the properties of the modern restorative materials, indications and contraindications for their use.

The tasks of the seminar. The student should know:

1. Classification of the modern restorative materials.
2. Composition, properties, indications for use of all groups of the materials for direct teeth restorations.
3. Rationale for the choice of modern restorative materials.

Requirements for the initial level of knowledge. For full understanding of the topic the student must revise:

– from human anatomy: anatomical features of different groups of teeth;

– from histology, cytology, embryology: histological structure of enamel, dentine and cementum;

– from general dentistry: composition and basic properties of restorative materials;

– from therapeutic dentistry: diagnosis and clinical features of caries and non-carious lesions, dental examination and treatment of dental diseases.

Control questions from related disciplines:

1. Anatomical structure of the tooth.
2. Blood supply and innervation of teeth.
3. Histological structure of enamel, dentine and cementum.
4. Dental materials: composition and basic properties.

Control questions for the seminar:

1. Classification of the modern restorative materials.
2. Dental amalgam: composition, properties, indications and contraindications for use.
3. Glass-ionomer cements. Classification, composition, properties, indications for use.

4. Resin-based composites. Classification, composition, properties, indications for use.

5. Comparative characteristics of the restorative materials based on their filler size, viscosity, resin matrix and cure type.

6. Contraindications for use of resin based composites.

7. Rationale for the choice of restorative materials in different clinical situations.

DENTAL AMALGAM

Dental amalgam is a mixture of a silver alloy with the liquid element mercury. The alloy used in the traditional dental amalgams consists of silver, tin, copper and sometimes zinc and/or mercury (Table 1).

Table 1

Constituents of a typical dental amalgam alloy

Constituent	% of total
Silver (Ag)	65–74
Tin (Sn)	25–28
Copper (Cu)	0–6
Zinc (Zn)	0–2
Mercury (Hg)	0–3

Silver is the main constituent, present in combination with tin as the intermetallic compound Ag_3Sn, known commonly as the γ phase. The setting reaction between the Ag-Sn alloy and the mercury is initiated by a vigorous mixing of the two ingredients:

$$Ag_3Sn + Hg \rightarrow Ag_3Sn + Ag_2Hg_3 + Sn_7Hg$$

$$\boldsymbol{\gamma} + \text{mercury} \rightarrow \boldsymbol{\gamma} + \underbrace{\boldsymbol{\gamma_1} + \boldsymbol{\gamma_2}}$$

$$\text{Powder} + \text{liquid} \rightarrow \text{unreacted alloy} + \text{amalgam matrix}$$

γ_2 phase is the weak link within the amalgam structure as it is soft and corrosion-susceptible.

The development of silver alloys with higher (12 % to 30 %) copper proportion has replaced traditional amalgams because it resulted in a modification of the setting reaction. The first reaction is the same as for the traditional alloys, but this is followed by a second reaction:

$$\gamma_2 + \text{Ag-Cu} \rightarrow Cu_6Sn_5 + \gamma_1.$$

Thus, the final amalgam contains little or no γ_2. It has higher compressive strength, more rapid set, reduction in creep and reduced susceptibility to corrosion.

Particles of the silver alloy powder can be either irregularly shaped, spherical, or a mixture of the two (Fig. 1).

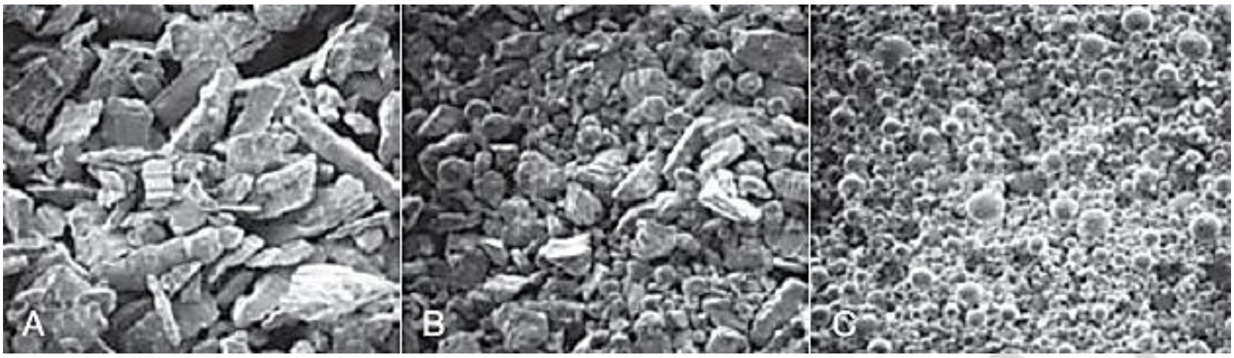


Figure 1. Scanning electron micrographs of silver alloy particles used in dental amalgam: *A* — irregular; *B* — “admixed”; *C* — spherical

The shape of these particles will significantly influence the setting reaction and manipulation of the amalgam. Amalgams containing irregular particles require greater packing forces during placement, but produce better proximal contacts and are easier to carve. Spherical amalgams require less mercury, less condensation force and set somewhat faster.

The laboratory and clinical evidence indicates that an admixed zinc-containing, high-copper content amalgam is the preferred choice. In today’s dental practice, the use of precapsulated amalgam is mandatory.

Modern dental amalgams have many **advantages**:

– high mechanical strength and wear resistance;

– durability;

– lower cost compared to other restorative materials;

– simple and fast filling technique;

– lower sensitivity to moisture;

– lower sensitivity to oral hygiene level;

– possibility to create tight contact point;

– high radiopacity.

However, dental amalgams also have a number of **shortcomings**:

– poor esthetics;

– high thermal conductivity (varnishes or liners are needed);

– galvanic effects;

– lack of adhesion (the need for retentive cavity design that requires removal of sound enamel and dentine);

– mercury waste management.

In 2011 World Health Organization (WHO) committee called for a worldwide reduction in the use of dental amalgam to cut the flow of mercury into the natural environment.

Indications for use of amalgam:

1. Moderate to large restorations in Class I and Class II cavities.
2. Class V restorations (when esthetics is not important).
3. Core build-up.

Amalgam is a preferable restorative material for the patients with bad oral hygiene, in cases when moisture control is difficult and when economic reasons are of the prime concern.

Contraindications for use of amalgam:

1. An allergy to any metal element of amalgam.
2. High esthetic requirements to restoration.

Thus, dental amalgam will continue to be one of the most convenient restorative materials for posterior use. Nevertheless, aesthetic demands from patients, desire on the part of the dentist to preserve tooth structure and ecological concerns will drive down the use of this material in dentistry.

GLASS IONOMER CEMENTS (GICs)

GIC is a true acid-base material, where the base is a fluoroaluminosilicate glass with a high fluoride content, and this interacts with a poly(alkenoic) acid. The polyacids most frequently used in current formulations are copolymers of acrylic and itaconic acid or acrylic and maleic acid. The result is a cement consisting of glass particles surrounded and supported by a matrix arising from the dissolution of the surface of the glass particles in the acid (Fig. 2).

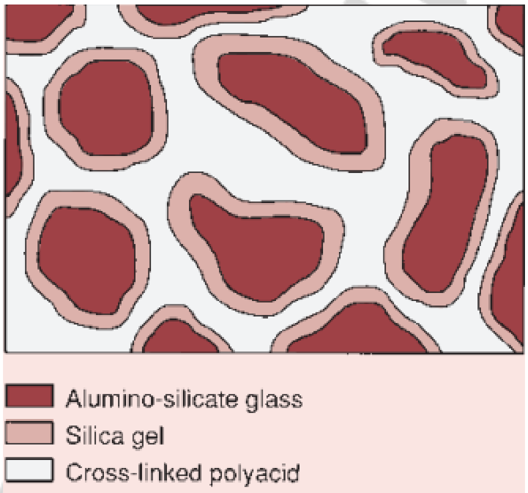


Figure 2. The structure of a GIC

At the same time some of the fluoride is released from the glass in the form of micro-droplets that lie free within the matrix, but play no part in its physical make-up. More fluoride is retained in the matrix, bonded to aluminium, and most of the subsequent fluoride release is the result of ion-exchange reactions. Thus the fluoride is able to leach out of the restoration as well as return into it with no modification at all of the physical properties of the set restoration. This means that GIC, in any form, can be regarded as a fluoride reservoir.

Properties of GICs

Chemical adhesion. One of the most attractive features of GICs is their ability to bond directly to dentine and enamel, forming hydrogen bond type of adhesion to the collagen combined with an ionic bond to the apatite (Fig. 3).

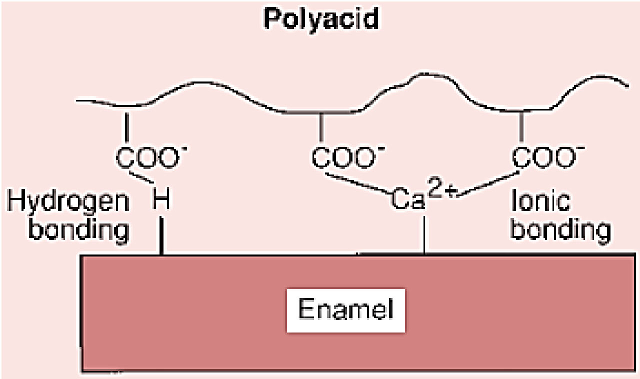


Figure 3. Adhesive mechanisms for GICs

Caries protective effect. It's still a matter of debate weather fluoride release or other factors (e.g. the release of other ions, antibacterial properties and adhesive capabilities) have a role to play in the anticariogenic characteristics of GICs. Nevertheless, these materials are widely recommended for patients with a high risk of caries.

Biological compatibility. It has been shown that the dental pulp demonstrates a very high level of tolerance to the presence of GIC. The poly(alkenoic) acids of the system are relatively mild acids with long and complex molecular chains, which will not readily penetrate dentine tubules, and the dentine itself is a very effective buffer to acids in general. Therefore, GIC can be placed in very close proximity to the pulp without the risk of developing an irreversible pulp inflammation.

Solubility. Dissolution of immature cement occurs before the material is fully set which can take up to 24 h. The temporary protection of GIC surface with waterproof varnish should be sufficient to minimize this effect.

Physical properties. GICs have expansion coefficient comparable to that of tooth structure. Their modulus of elasticity is similar to that of dentin. GICs have rather good compressive strength, but their fracture resistance and abrasion resistance are relatively low. They are still not recommended for rebuilding cusps, marginal ridge or incisal corner.

Aesthetics. In GICs the color is produced by the glass. This can be controlled by the addition of color pigments. Whereas color does not present a major problem, the translucency of some GICs is inadequate. One more problem is insufficient polishing, which doesn't provide the quality of the surface close to natural tooth. That's why aesthetic appearance of GICs has always been considered inferior to that of composite resins.

Classification of GIC by composition:

1. Traditional GICs (auto cure):
– classical;
– anhydrous;
– cermets (ceramic-metal mixtures).
2. Resin-modified GICs (RMGICs).

Traditional GICs are 2-component auto cure materials. In *classical* ones powder is a F-Al-Si glass, liquid is a water solution of polyacids. *Representatives*: Fuji II (GC), Ionofil Plus (VOCO), Ketac Universal (3M).

In *anhydrous* cements the glass powder is blended with freeze-dried polyacid and tartaric acid powder. The cement is formed by the addition of the correct amount of distilled water. *Representatives*: Aqua Ionofil Plus (VOCO), ChemFil Superior (Dentsply).

In *cermets* the glass particles are covered with a fine layer of metallic silver. This leads to improved handling properties and abrasion resistance. Compressive strength and fracture resistance have also been improved to a limited extent. *Representatives*: Argion (VOCO), Ketac Silver (3M), MiracleMix (GC).

The main difference of *RMGICs* is the addition of resins and photo-initiators to the auto cure materials so that they can be light-cured on command immediately after placement in the cavity. These materials are immediately resistant to water uptake and can be contoured and polished as soon as they are set. Their physical properties are generally better and esthetic features are also improved. *Representatives*: Ionogem LC (DCL), Fuji II LC (GC), Photac-Fil Quick (3M), Ionolux (VOCO), Geristore (DenMat), Vitremer (3M).

Classification of GICs by clinical indications:

Type I: Luting and bonding GICs

● For cementation of crowns, bridges, inlays and orthodontic appliances as well as bonding of composite resins and amalgam

● Fast set, with early resistance to water uptake or light-activated

● Ultimate film thickness 20 µm or less

● Radiopaque

Type II: Restorative GICs

II.1: Restorative esthetic GICs

● For any application requiring an esthetic restoration with minimal occlusal load.

● Excellent shade range and translucency

● Auto cure cements have a prolonged setting reaction and remain subject to water loss and water uptake for at least 24 hours after placement; they require immediate protection from the oral environment.

● Resin-modified materials are immediately resistant to water uptake or water loss; they do not require sealing.

● Most materials are radiopaque.

II.2: Restorative reinforced GICs

● For use where aesthetic considerations are not important, but a rapid set and high physical properties are required.

● Fast set with early resistance to water uptake; can be trimmed and polished immediately after initial set; remain susceptible to dehydration for 2 weeks after placement.

● Radiopaque.

Type: III Lining or base GICs

● Can be auto cure or resin-modified.

● Can be used as either a lining or a base, depending on the powder-liquid ratio used.

● Physical properties improve as the powder content increases.

● Radiopaque.

Indications for use of GICs:

1. Restorations of Class III and V cavities in permanent teeth. Small Class I cavities in non-occlusal areas.
2. Non-carious cervical lesions.
3. Root caries.
4. Temporary restorations of permanent teeth.
5. Use as a liner or a base in "sandwich technique".
6. All classes of cavities in deciduous teeth.
7. Atraumatic restoration technique (ART).
8. GIC-protection of fissures.
9. Use as a sealer in endodontic treatment.
10. Luting procedures.

GICs are preferable restorative materials in patients with bad oral hygiene and high caries risk, in subgingival cavities with challenging moisture control and in situations when resin composites are contraindicated.

Hence, GICs have had a major impact on restorative dentistry. A wide variety of formulations are now available, designed for a broad range of applications. The new RMGICs have produced materials with superior properties. However, these improvements are as yet insufficient for them to compete with the resin composites in high-stress-bearing areas in the permanent dentition.

RESIN-BASED COMPOSITES (RBCs)

A composite, as the name implies, consists of a mixture of two or more materials. Each of these materials contributes to the overall properties of the composite.

RBC restorative materials that are used in dentistry have three major components:

– an organic resin matrix;

– an inorganic filler;

– a coupling agent.

The resin is chemically active component of the composite. It is initially a fluid monomer but is converted into a rigid polymer by a radical addition reaction. The most commonly used monomers are Bis-GMA and UDMA. They are highly viscous fluids because of their high molecular weights. To overcome this problem, low-viscosity monomers (EDMA, TEGDMA) are added. Resin matrix also contains the activator/initiator systems for achieving the cure.

Quartz, lithium aluminum silicate, and barium, strontium, zinc, or ytterbium glasses have been used as fine fillers. Microfine fillers are colloidal silica particles. The fillers improve mechanical properties of the material, control various esthetic features, provide radiopacity and reduce the shrinkage, as the filler does not take part in the polymerization process.

To achieve strong bond between the resin and the filler silane coupling agents are used.

Classification of RBCs

By filler size:

1. Macrofilled (8–12 μm and more).
2. Microfilled (0.01–0.1 μm).
3. Hybrid (0.01–10 μm).
4. Nanocomposites:

– nanofilled (1–100 nm);

– nanohybrid (nanoparticles + hybrid filler).

By resin matrix:

1. Pure methacrylates (traditional composites).
2. Acid modified methacrylates (compomer).
3. Inorganic-organic matrix (ormocer).

By viscosity:

1. Regular.
2. Flowable (low viscosity).
3. Packable (high viscosity).

By cure type:

1. Auto cure.
2. Light cure:

– incremental;

– bulk-fill.

3. Dual cure.

Macrofilled RBCs contained glass filler particles with a mean particle size of 10 μm or more. These composites had the disadvantage that the surface finish was very poor, with the surface having a dull appearance due to filler particles protruding from the surface as the resin was preferentially removed around them. This group is not used much anymore.

Microfilled RBCs contain colloidal silica microfine particles with high surface areas. The small size of the filler means that the composite can be polished to a very smooth surface finish and exhibits good optical characteristics. However, only 35 % to 50 % by volume of these particles can be used with the resin matrix and still produce a paste of acceptable viscosity. That's why microfilled RCs are weaker, often insufficiently radiopaque, and perform poorly in the posterior region. They are indicated for Class III and V restorations. *Representatives:* Renamel Microfill (Cosmedent), GemLite II Micro (DCL).

*Hybrid RBC*s contain different-sized filler particles ranging from very small submicron size to several microns in average diameter. The microfine filler particles fit in spaces between the fine filler particles, producing a total filler load of 70 % by volume, which results in improved properties. Modern methods of grinding have allowed introduction of composites with an average particle size of less than 1 µm. These materials are called *microhybrids* and are most common today. They combine good mechanical properties with desirable esthetic features and can be used for **"all-purpose" indications:**

1. Correction of the esthetic parameters of the tooth:
a) correction of shade;
b) remodeling of shape and size;
c) adjustment of tooth position in dentition.
2. Restoration of carious, non-carious and traumatic lesions of teeth:
a) restoration of tooth crown after traumatic injuries;
b) Classes I-VI restorations.
3. Teeth splinting.
4. Core build-up.
5. Repair of direct and indirect restorations.
6. Indirect restorations (inlays, onlays, veneers).

Nanocomposites are defined as materials that include filler particles less than 100 nm. *Nanofilled* materials include solely nanoparticles, partially agglomerated in clusters with the size of 0.6 to 1.4 µm (Fig. 4). *Representatives:* Filtek Ultimate, Filtek Bulk Fill Posterior (3M). In *nanohybrid* composites nanoparticles are combined with larger filler particles (up to 3 µm). *Representatives*: Premise (Kerr), Ceram-X (Dentsply), Synergy Nano Formula (Coltène Whaledent), Grandio (VOCO).

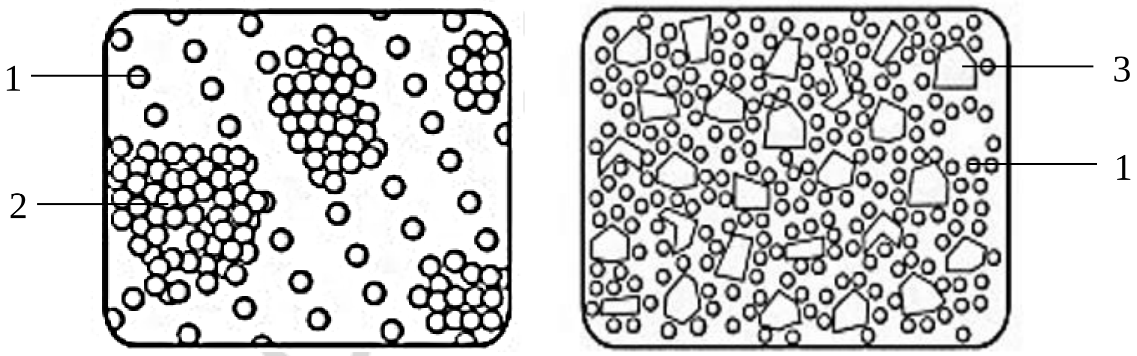


Figure 4. The difference between nanofilled and nanohybryd composites:
1 — nanoparticles; *2* — nanoclusters; *3* — microparticles

Due to the high filler load new nanocomposites have less polymerization shrinkage and better physical properties. They also produce a better polish because a nanosized particle is larger than the wavelength of light that is not reflected by the particle, so the material appears more translucent. Nanocomposites are used for "all-purpose" indications.

COMPOMERS

Compomers contain monomers modified by polyacid groups with fluoride-releasing silicate glasses and are formulated without water. Among current products, the filler-volume percentage ranges from 42 % to 67 %, and the average filler-particle size ranges from 0.8 to 5.0 µm. Compomers are packaged as single-paste formulations in compules and syringes. Setting occurs primarily by light-cured polymerization, but an acid-base reaction also occurs as the compomer absorbs water after placement.

The amount of fluoride release and its duration are lower than those of GICs. Also, compomers do not "recharge" from fluoride treatments. Unlike GICs, compomers do not have a natural affinity for enamel and dentine and must be used in combination with a dentine adhesive.

Compomers are mostly used for restorations in low-stress-bearing areas: Class III and V cavities in permanent teeth and all cavities in deciduous teeth. *Representatives:* Glasiosite, Twinky Star (VOCO), Compoglass F (Ivoclar Vivadent), F2000 (3M), Dyract eXtra (Dentsply Sirona).

ORMOCERS

Whereas methacrylate-based resin matrices consist of purely organic material, an alternative type of inorganic-organic copolymer resin was introduced more than 20 years ago. This developed into the ORMOCER®, which stands for ORganically MOdified CERamic. It consists of organic reactive species with carbon double bonds for polymerization, which is bound to an inorganic Si–O–Si network (Fig. 5).

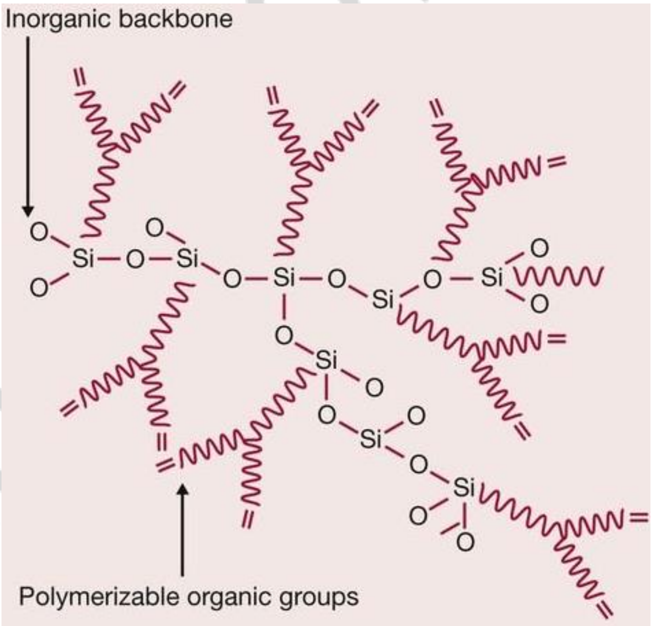


Figure 5. Ormocer chemistry

Ormocer has better biocompatibility compared to traditional methacrylate-based composites. Sufficient mechanical properties and satisfactory esthetics make it an "all-purpose" material. *Representative*: Admira (VOCO).

FLOWABLE RBCs

In order to produce low-modulus flowable RBCs, the manufacturers have reduced the filler loading to 42–53 % by volume. The low viscosity of these composites allows them to be dispensed by syringe for easy handling. These materials ideally suit for small preparations due to their good adaptation properties. They **are indicated** for:

1. Restoration of minimally invasive preparations of Class I (out of occlusion), III and V cavities.
2. First ("adaptive") layer of composite restorations.
3. Preventive resin restorations (for pits and fissures).
4. Teeth splinting with fiber glass tape.
5. Margin repairs.
6. Elimination of undercuts for indirect restoration technique.

Nevertheless, flowable composites exhibit higher polymerization shrinkage and lower strength and wear resistance than microhybrids. These materials are not recommended for situations involving high levels of stress or wear.

Representatives: Esthet Xflow (Dentsply Sirona), Tetric EvoFlow (Ivoclar Vivadent), Premise Flowable (Kerr), Filtek Ultimate Flowable (3M), Charisma flow (Kulzer).

PACKABLE RBCs

Packable composites have handling characteristics similar to those of dental amalgams due to increase in filler loading of 1–2 vol. % and a change in the rheology. This is not as easy as it sounds since the filler loading of most composites has already been maximized and simply adding more filler will make the composite crumbly and cause cracking. The increased viscosity can be accomplished in a number of different ways:

– by increasing the filler particle size range, which improves the packing density, such as a trimodal particle size distribution (Fig. 6);

– by modification of the filler particle shape such that particles have a tendency to interlock;

– by modification of the resin matrix such that stronger intermolecular attractions are created;

– by the addition of dispersants (rheological control additive), which lower the viscosity and allow an increase in the filler loading.

Important properties include high depth of cure, low polymerization shrinkage, radiopacity, and low wear rate. However, these materials tend to be more opaque and their adaptation can be a problem due to the high viscosity. Therefore packable composites have a limited range of applications and are most suitable for posterior restorations, such as Class I and II preparations. *Representatives*: Filtek P60 (3M), Aelite LS Posterior (Bisco), QuiXfil (Dentsply), Alert (Pentron), X-tra fil (VOCO).

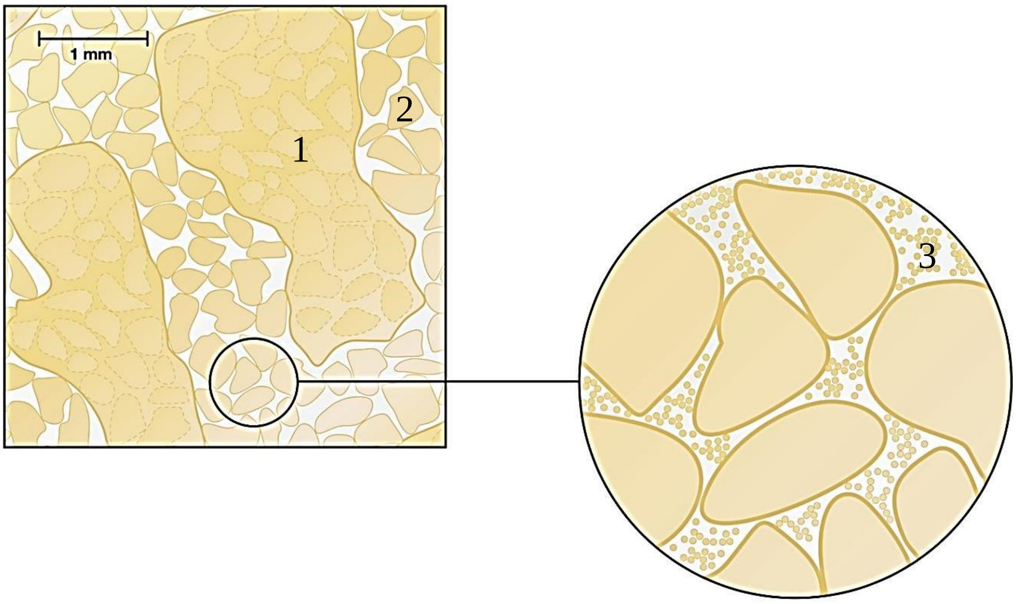


Figure 6. Trimodal particle size distribution:
1 — pre-polymerized filler; *2* — microfiller; *3* — nanoparticles

BULK FILL RBCs

Most of the light-cured RBCs require incremental technique of cavity filling in order to control depth of cure and shrinkage. In order to simplify and speed-up the placement of large posterior RBCs, manufacturers have produced a range of materials which can be placed in larger increments (up to 4–10 mm), known as bulk-fill composites. They differ most from conventional composites in their increased depth of cure, which could mainly be attributed to an increase in translucency. There are two categories of bulk-fills: low viscosity flowables (e.g., SDR, Filtek Bulk Fill Flowable, X-tra Base, Venus Bulk Fill), and high viscosity restoratives (*e.g.*, Tetric EvoCeram Bulk Fill, X-tra Fil, SonicFill). Flowable bulk-fill material is placed at the bottom of the preparation as dentine replacement and should be covered with a layer of conventional composite (Fig. 7).

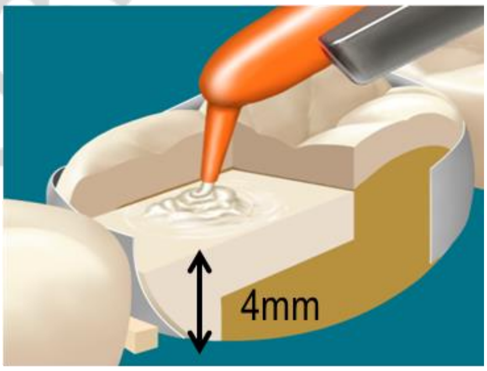


Figure 7. Schematic illustration of dentine replacement with flowable bulk-fill composite

High-viscosity bulk-fill doesn't need any additional capping. To date, more clinical studies that specifically focus on bulk-filling deep and large restorations are definitely required to fully explore the clinical benefits of these composites.

CONTRAINDICATIONS FOR USE OF RBCs

Absolute contraindications:

1. Allergic reaction to any component of RBC material.
2. Inability to adequately isolate the operation field.
3. If the patient has a heart pacemaker implant the dentist needs to consult with the cardiologist about the possible use of the light curing unit.

Relative contraindications:

1. Poor oral hygiene.
2. Deep subgingival cavities.
3. Occlusal overload of restoration (bruxism, orthodontic abnormalities, teeth attrition, large restorations, etc.).

The introduction of resin-based composite restorative materials has had a major impact on the practice of restorative dentistry. Their clinical applications are numerous and varied, and will continue to grow as further improvements in their properties are achieved. However, there are certain limitations for the use of this group of materials and it is important that these should not be disregarded.

RESTORATIVE TECHNIQUES

MOTIVATIONAL CHARACTERISTIC OF THE THEME

Total time: 70–90 minutes (seminar).

Direct restoration of tooth is a basic procedure in conservative dentistry. Today there are plenty of restorative materials on the market. The advances in the field of dental materials have changed the traditional concepts of restorative dentistry and resulted in the development of innovative preparation and filling techniques. To get precise and predictable results of work professionals should be familiar with modern restorative techniques and understand workflow in details. In that regard, it is important to summarize the information on the features of clinical use of various restorative materials. High level of knowledge on the subject will improve the efficiency of restorative treatment of hard tooth tissues.

The purpose of the seminar: to integrate knowledge about fundamentals of direct restorations of teeth using different types of the modern restorative materials.

The tasks of the seminar. The student should know:

1. Basic rules of preparing for the tooth restoration.
2. Steps of teeth restorations with resin-bonded composites (RBCs), glass ionomer cements (GICs), dental amalgams.
3. Restorative techniques utilizing different types of filling materials.

Requirements for the initial level of knowledge. For full understanding of the topic the student must revise:

– from human anatomy: anatomical features of different groups of teeth;

– from histology, cytology, embryology: histological structure of enamel, dentine and cementum;

– from general dentistry: methods of preparation of dental hard tissues;

– from therapeutic dentistry: diagnosis and clinical features of caries and non-carious lesions, classification of dental restorative materials, rationale for choice, indications and contraindications for use of resin composites, GICs and dental amalgams.

Control questions from related disciplines:

1. Anatomical structure of the tooth.
2. Blood supply and innervation of teeth.
3. Histological structure of enamel, dentine and cementum.
4. Methods of preparation of hard dental tissues.
5. Indications and contraindications for use of different classes of direct restorative materials.

Control questions for the seminar:

1. Basic rules of preparing for the tooth restoration.
2. Modes, instruments and techniques of preparation of dental hard tissues.
3. Pulp protection.
4. Adhesive techniques.
5. Steps of tooth restoration using resin composite.
6. Steps of tooth restoration using GIC.
7. Steps of tooth restoration using dental amalgam.
8. Recommendations for the patients after direct restorative procedure.

BASIC RULES OF PREPARING FOR THE TOOTH RESTORATION

Oral hygiene. The patient must have satisfactory oral hygiene before advanced restorative procedures, otherwise failure is inevitable. As with any other adhesive bond, it is important that the surface of the substrate should be thoroughly cleaned. The surface of enamel is covered with a layer of pellicle and possibly a layer of plaque, calculus and stains as well. Such layers need to be removed before the etching process. Whereas a thin layer of pellicle may be stripped off by the acid, it is not possible to remove thick deposits of plaque in this way. If this cleaning is not done, restorative material will bond to the surface contaminants and not the enamel. Poor oral hygiene may also affect proper shade selection and the quality of isolation as gingival bleeding will not allow getting dry working field. Sometimes placing a well-contoured temporary restoration to resolve the gingival inflammation is a necessary first step.

Check of occlusion. Before starting preparation procedures it's useful to check occlusal contacts. The border of the cavity should not pass through the occlusal points as this will cause marginal defects. Margins of the restoration should be located either inwards or outwards of the occlusal points. In the latter case the layer of restorative material under occlusal contact should be not less than 2 mm.

Local anesthesia. When required, local anesthesia is given since it eliminates pain and discomfort of patient during treatment and makes the procedure more pleasant, effective and time saving for both the patient and the clinician. For the cavity preparation it’s safer to use local anesthetics with low adrenaline concentrations (1 : 200,000 or less).

Cavity preparation. Adequate cavity preparation is one of the most important factors ensuring the effectiveness of restorative treatment. There are different methods of dental hard tissues preparation:

– mechanical — conventional use of handpieces, burs and hand instruments;

– chemomechanical — combination of gels (Carisolv) and hand instrumentation;

– kinetic — air abrasion technique, that uses a stream of small aluminum oxide particles, created using pressurized air;

– sonic — the use of diamond-coated tips oscillating at a high frequency;

– laser — the use of Er:YAG laser for thermomechanical ablation of tissues.

It should be noted that only mechanical preparation is universal for all types of cavities. Other methods have various restrictions or require a combined approach.

For high-quality preparation the proper choice of burs is essential. The main characteristic of a *diamond* bur is its abrasiveness. The information on color coding, grain sizes and indications for use of diamond burs are summarized in Table 2.

Table 2

Color coding of abrasiveness and indications for use of diamond burs

Color code	Abrasiveness	Average grain size, µm	Purpose
Black	Very rough	180	For quick preparation
Green	Rough	135	For quick preparation
Blue (no color)	Normal	100–120	Universal
Red	Thin	50	Finishing
Yellow	Very thin	30	Polishing
White	Ultra thin	15	Final polishing

Diamond burs are not suitable for dentine preparation because they become deteriorated with organic substances, overheat the dentine and cause the formation of a thick smear layer.

Tungsten carbide burs have high cutting ability and are effective for the preparation of enamel, dentine, resin composites, dental amalgam and other materials.

Stainless steel burs are used at low speed and cut only dentine effectively (Table 3).

Table 3

The choice of burs for preparation of cavities and restorative materials

Material	Burs		
	Stainless steel	Tungsten carbide	Diamond
Enamel	–	±	+
Dentine	±	+	±
Amalgam	–	+	±
Resin composite	–	+	+
GIC	–	+	+

+ recommended; ± possible; – not suitable.

D. W. Boston (2000) described a polymer bur that only removed softened and infected dentin and not normal dentin. The cutting elements of the bur were made of a softer polyamide/imide polymer material than the traditional carbide bur.

The mode of preparation is also important. *Enamel* preparation is performed using high-speed handpiecies with sufficient water cooling. *Dentine* preparation is more efficient and safe at low speeds. All the burs used should be sharp, centered and sterile.

Hand instruments for cavity preparation are not widely used now due to the great improvements in rotary tools. The most popular ones are excavators, gingival margin trimmers and enamel knifes.

Isolation of the operating field. The use of rubber dam is the most reliable and effective method of moisture control in restorative dentistry. It eliminates saliva from the operating site, retracts the soft tissues and defines the operating field by isolation of one or more teeth from the oral environment. Usually rubber dam is used before starting preparation procedure.

If rubber dam is not used, operating field is isolated after cavity preparation. Relative dryness is achieved by using cotton rolls, dry tips, aspiration systems, tissue retractors, tongue guards, etc.

RESIN COMPOSITE RESTORATION TECHNIQUE

The main requirement for the resin composite use is precise compliance with manufacturer's instructions. Despite some variations in different products there are a number of general principles for their application.

1. Cleaning of a tooth surface. The cleaning procedure should be carried out by scrubbing for a few seconds with a slurry of pumice and water in a soft rubber cup or bristle brush. Prophylaxis pastes can also be used, but they shouldn't contain any oil or fluoride as this will compromise bonding efficiency. Proximal surfaces are cleaned with the dental floss. An alternative way to remove biofilm, stains and pellicle is air polishing technology (Air-flow). Once the surface has been cleaned, it should be thoroughly washed and dried to remove all the debris.

2. Shade selection. Shade taking is recommended before isolation and preparation steps as the dried surface of the tooth looks lighter. All color contrasts should be avoided (rubber dam, lipstick, gloves, etc.). The tooth surface must be clean and wet. Recommended lighting should replicate northern natural midday daylight.

The most convenient method of shade selection is the use of commercial shade guides (Vita Classic, Vitapan 3D Master). Tabs of similar *hue* are clustered into letter groups — A, B, C, D. *Chroma* is indicated by the numbers (from 1 to 4). *Value* is the characteristic of the tooth lightness.

At this step it's also important to plan the use and interaction of different opacities (dentin, enamel, body, translucent shades) of restorative material to get the natural esthetic result.

3. Check of occlusion.

4. Local anesthesia.

5. Isolation of operating field. This step is very important particularly for the resin composite restorations, because these materials are highly hydrophobic and adhesive technique requires absolutely dry working field. Rubber dam is the safest way to avoid contamination of the cavity with blood, saliva and gingival fluid.

6. Cavity preparation. Includes several steps:

– cavity access and outline form;
– cavity extension;
– necrectomy;
– cavity shaping;
– finishing of enamel margins.

Cavity access and outline form. Preparation starts with removal of all the weakened and unsupported enamel to get sufficient access to the cavity walls and to place the margins of preparation in a position to afford good finishing of the restoration. At this step diamond and carbide burs are used at high speed with adequate cooling.

Cavity extension. The principle "extension for prevention", introduced by G. V. Black, has changed now to "prevention of extension" due to fluoride-induced remineralization, advancements in instrumentation, restorative materials and adhesive techniques. Preparation margins can be extended only if they pass through the occlusal contacts.

Necrectomy. This step means complete removal of all the softened and infected dentine from the cavity. For this purpose carbide and stainless steel round burs are used at low speed. In deep cavities excavators can also be useful.

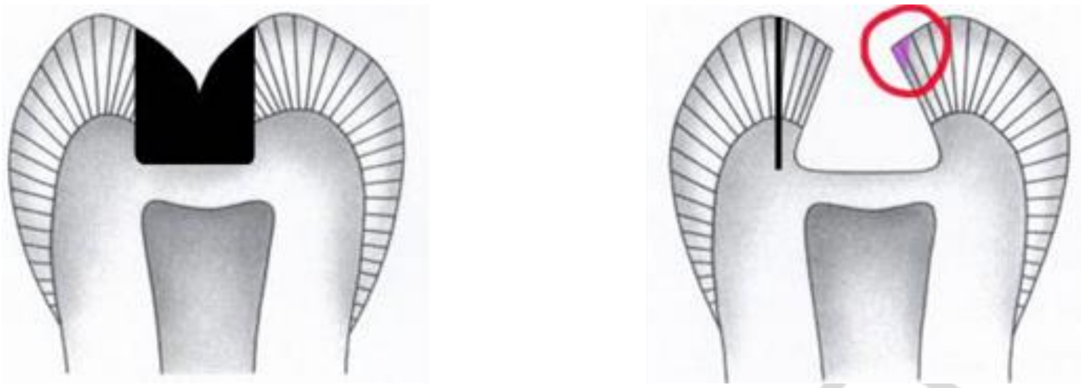
Cavity shaping. External and internal outline contours of the cavity should be rounded with smooth transition lines between the bottom and cavity walls. When using adhesive technique preparation should be as conservative as possible.

Finishing of enamel margins. Finishing of the enamel margins should be done irrespective of the restorative material used. To remove marginal cracks, irregularities and fragmented enamel rods diamond burs (red label) and carbide burs (10–12 blades) are used.

Enamel bevel. Enamel bevel is prepared to increase the surface area of enamel rods for bonding. There is no need for beveling in small-to-medium size cavities of Class I and II since conservative 90-degree exits in central pits already expose many enamel rod ends. Large restorations do not expose many rod ends, so a short bevel (0.5 mm) preparation is recommended (Fig. 8).

In Class III, IV, V cavities long "wavy" bevel $\approx$ 2 mm is prepared on the vestibular surface of the tooth (Fig. 9). Oral surface needs only short beveling.

7. Cavity cleaning. It's important to remove all the debris from the preparation, especially on the margins, otherwise deposits left on them consequently dissolve, resulting in microleakage which further can result in secondary caries. Cleaning of preparation can be done by using water or 2 % chlorhexidine. It's not recommended to use hydrogen peroxide (inhibits resin polymerization) or eugenol (compromises adhesion). Drying of the cavity can be done using air.



a ***b***

Figure 8. Enamel preparation in Class I and II cavities (R. Hickel, 2006):
a — many exposed enamel rod ends (no beveling); *b* — not exposed enamel rod ends in wide cavities or undermined enamel (short bevel 0.5 mm)

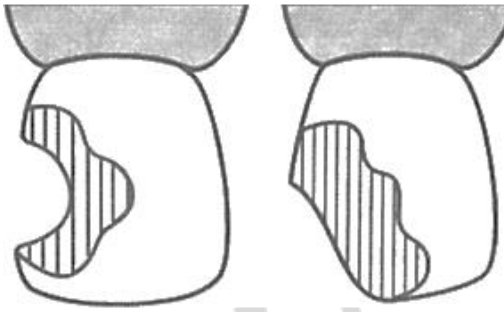


Figure 9. Long flat “wavy” bevels on the vestibular surfaces of frontal teeth (A. V. Salova, 2003)

8. Pulp protection. If the thickness of deep dentin is less than 1 mm pulp protection is recommended. There are several options to protect the pulp:

– to use GIC liner/base;

– to apply calcium hydroxide to those areas of preparation in which there is the potential for pulp exposure and then cover it with GIC;

– to cover the bottom of the cavity with Biodentine (Septodont);

– to use mineral trioxide aggregate (MTA).

If the restoration should be finished at one appointment it’s preferable to use resin modified GIC (RMGIC) as it sets quickly and has better adhesion to resin composite.

9. Application of adhesive system. Selected bonding system is applied according to the manufacturer’s instructions.

Use of total etch&rinse systems. For simultaneous etching of both enamel and dentin phosphoric acid gel (20–40 %) is used. The sequence of the procedure:

– start application of the etching gel to enamel;

– let the gel act on enamel for 15 s;

– extend the etching gel onto dentine;

– let the gel react for another 15 s (not longer to avoid disintegration of the collagen fibers);

– carefully rinse off the etching gel for 15–30 s;

– do not dry excessively. Restrict the use of compressed air to just remove gross excess of water from the cavity with shot air blasts;

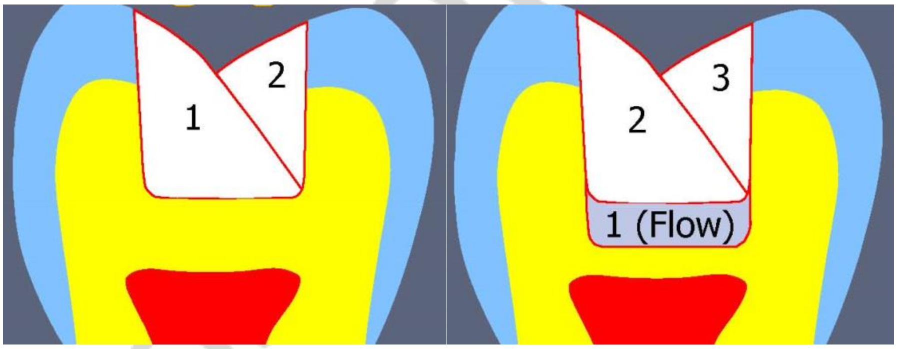
– apply the primer and adhesive (or one-bottle primer-adhesive) according to the manufacturer's instructions;

– light cure.

Use of self-etch systems. When using these systems there is no need for separate etching, rinsing and drying steps. In two-step systems self-etch primer is applied first to both enamel and dentine, gently scrubbed for 20 s and air-dried to evaporate the solvent. Then adhesive is applied and light cured. In all-in-one adhesives a self-etch primer-adhesive is applied in a single step.

Use of universal adhesive systems. These adhesives work well with either the total-etch, self-etch or selective-etch (only enamel is etched with phosphoric acid) technique.

10. Cavity filling. There are different techniques to fill the preparation. Most of light-cured resin composites are applied incrementally in thin layers (not more than 2 mm). Dentists use incremental placement techniques for a variety of reasons: cure depth of the composite, management of shrinkage stress, more precise manipulation of the restorative to ensure adaptation, creating multi-shade restorations. Oblique layers are used to reduce polymerization stress (Fig. 10, *a*). To improve internal adaptation flowable composite/compomer can be placed to the bottom of the cavity (Fig. 10, *b*).



a ***b***

Figure 10. Layering techniques:
a — oblique layers; *b* — C-b-F technique (composite bonded to flowable)

In very large preparations a build-up base with GIC ("sandwich-technique") will reduce the volume of shrinking composite, thus reducing the risk of enamel cracking.

On the other hand, incremental placement is considered time consuming and tedious, especially in posterior teeth. Increments may increase the potential of voids and the risk of contamination. Bulk fill composites allow filling the cavity in larger increments (up to 4–10 mm). The thing to remember is the flowable bulk-fills should be covered with the layer of sculptable composite.

The rules of light curing:

– Inspect and clean the light curing unit (LCU) before use to ensure it is on the correct setting, good working order, and free of defects and debris.

– Follow the light exposure times and increment thickness recommended by the resin manufacturer. Increase your curing times for increased distances and darker or opaque shades.

– Position the light tip as close as possible (without touching) and parallel to the surface of resin composite being cured.

– Stabilize and maintain the tip of the LCU throughout the exposure.

– Always use the appropriate "blue-blocking" glasses or a shield to protect your eyes as you watch and control the position of the curing light.

11. Finishing and polishing. This step is carried out to adjust occlusion and anatomical shape of the tooth, ensure ideal marginal adaptation of the material, remove oxygen-inhibited layer and obtain surface gloss close to that of enamel. Recommended instruments: fine diamond and tungsten carbide burs, rubber tips, flexible discs, abrasive impregnated brushes, strips, polishing pastes.

12. Fluoride application. All the tooth surfaces adjacent to the restoration are protected with fluorides to enhance remineralization. Colorless fluoride varnishes are used.

GLASS IONOMER CEMENT RESTORATION TECHNIQUE

All the GICs, represented on the market, belong to one class of materials in terms of their chemical composition, so the basic rules of their clinical application are the same.

1. Cleaning of a tooth surface. Microbial biofilm is removed from the tooth surface with rubber cup / brush and polishing paste.

2. Shade selection. This step is carried out only for the esthetic GICs.

3. Check of occlusion.

4. Local anesthesia. Steps 3 and 4 are performed in accordance with the above principles.

5. Cavity preparation. The steps of cavity preparation for GIC restoration are similar to those for RBC restoration. The only exception is that enamel is finished but not beveled.

6. Isolation of operating field. In contrast to RBCs, GICs are less sensitive to the moisture. Nevertheless, excess moisture can promote the leaching of calcium and aluminum ions, which ultimately affects the physical properties of the material. In most cases, it is sufficient to isolate the working field by means of adsorption rolls and aspiration systems.

7. Cavity cleaning.

8. Pulp protection. If the cavity is very deep and there may be a micro-exposure of the pulp, then it is recommended that a calcium hydroxide lining is placed on the pulpal aspects of mechanically prepared cavities prior to the insertion of the GIC. In all other cases when there is a residual dentine layer, dentine bridge formation will occur without any additional pulp protection.

9. Cavity conditioning. Chemical adhesion is available between the GIC and the underlying tooth structure, provided that the smear layer and other debris have been removed first by conditioning with 10 % poly(acrylic) acid for 10–15 seconds. This is a relatively mild acid that will partially dissolve the smear layer without demineralizing of the remaining dentine and without opening up dentinal tubules. There are two additional advantages in using this particular material for conditioning the dentine. Firstly, since it is the same acid that is utilized in the glass-ionomer itself, any residue inadvertently left behind will not interfere in the setting reaction. Secondly, it will modify the surface tension and therefore enhance the wettability of the tooth surface. This leads to pre-activation of the calcium and phosphate ions in the tooth structure, rendering them more available for ion exchange with the GIC.

In some modern GICs (Ketac Universal, Vitrebond, etc.) conditioning step is unnecessary and can be omitted. In RMGIC Vitremer conditioning also is not performed, but special acidic primer is used to modify the smear layer and wet the tooth surface. This primer is applied with a brush for 30s, then air dried and light cured.

10. Mixing of GIC. The powder-liquid ratio should carefully follow manufacturer's instructions as it has a significant bearing on ultimate physical properties of the material.

– When it is recommended, shake the bottle of powder, and then use the spoon supplied for that particular material;

– Level off the powder in the spoon on the lip of the bottle;

– To dispense the liquid accurately turn the bottle horizontally first and allow the liquid to flow into the spout. Then turn vertically and dispense a drop that is free of air bubbles;

– Immediately incorporate one half of the powder with the spatula, mix this in as rapidly as possible. In 10 seconds add the remaining powder and continue mixing with a rolling motion.

– By 30 second the mix must be complete. Any continuation of handling will begin to break up the newly forming polyacrylate chains and weaken the ultimate material.

The use of capsulated materials is strongly recommended because this simplifies dispensing and mixing and increases the reliability of the end-result.

11. Placement of GIC. Material is placed into the cavity with either hand instrument, disposable syringe or a capsule. Contamination with saliva should be avoided. The material should be allowed to set for the required time. RMGICs are used in 2mm layers or in bulk (e.g. Vitremer) and light cured.

12. Protection of GIC. Auto cure esthetic GICs (type II.1) are slow to set and require immediate protection from the oral environment in order to minimize water uptake and dissolution. The maintenance of water balance for at least 24 hours is strongly recommended for this particular group, because it allows optimum development of esthetics. Right after cavity filling the surface of the material is sealed with special varnish or light-activated unfilled bonding resin. It's recommended to delay final finishing of these restorations for at least one day.

All other types of GICs will be resistant to water uptake after setting and require protection from dehydration only (after finishing).

13. Finishing of the restoration. Because of the rapid-setting chemistry, restorative reinforced GICs and RMGICs can be contoured and polished as soon as they have set hard. Finishing is carried out using fine diamond or 12-bladed tungsten carbide burs. This should be carried out in the presence of a copious supply of water to avoid dehydration. Polishing can be performed with the range of abrasive discs and rubber cups again in the presence of water. Application of low-viscosity resin glaze over the final surface will fill the porosities and protect the material from dehydration. Care must be taken not to leave an excess of glaze, so forming a ledge or overhang.

DENTAL AMALGAM RESTORATION TECHNIQUE

1. Cleaning of a tooth surface. Dental plaque is removed from the tooth surface with a rubber cup / brush and polishing paste. In this case, the presence of fluoride or oil in the paste formulation is not of fundamental importance.

2. Check of occlusion.

3. Local anesthesia. Steps 2 and 3 are performed in accordance with the above mentioned principles.

4. Cavity preparation. Since dental amalgam has no adhesive qualities, it requires proper cavity design to provide macromechanical retention.

The shape of the preparation should resemble a box with a flat floor. This helps the tooth to resist occlusal masticatory forces without any displacement. To provide adequate thickness of amalgam the minimum occlusal depth of the cavity should be not less than 1.5 mm.

For better retention buccal and lingual walls are prepared with occlusal convergence (from 2 to 5 %).

The presence of sharp internal line angles concentrates stress at these sites, which increases the risk of fracture of both the tooth and the filling (Fig. 11). So such sharp angles are avoidable, and rounded internal surfaces should be the aim.

Marginal breakdown is less likely to occur with cavo-surface angles greater than 70°, as this avoids thin wedges of the amalgam. The practice of cutting perpendicular cavity walls on the occlusal aspect of the cavity is conducive to producing an acute margin angle for the amalgam. Changing the angle for the whole of the cavity wall is not possible, as this may cause the cavity outline to come close to the pulp horn or to perforate it. An acceptable method of overcoming this problem is to confine the sharp angulation to the enamel only (Fig. 12).

Thin cusps should be cut and capped with amalgam to prevent their fracture. For better retention occlusal dovetail can be prepared. The last step of preparation is finishing of enamel margins without beveling.

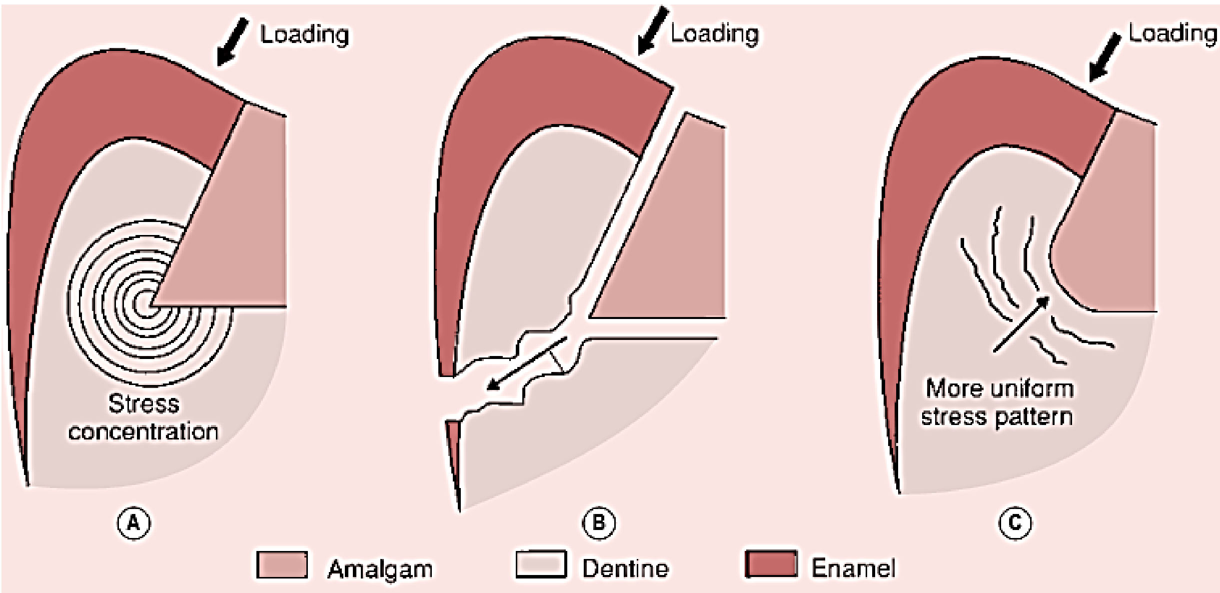
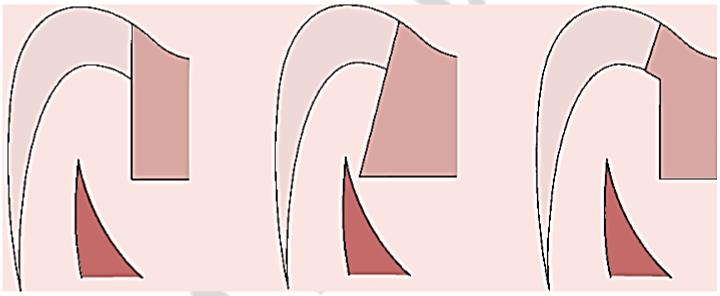


Figure 11. Internal line angles:
A — a sharp internal angle concentrates stress; *B* — this may lead to a cusp fracture under heavy occlusal loading; *C* — tensile stresses can be considerably reduced by creating rounded line angles



A ***B*** ***C***

Figure 12. Cavo-surface angle:
A — an acute margin angle in the restoration that will lead to marginal fracture and should be corrected; *B* — the cavo-surface angle is now closer to the ideal but may give rise to a pulpal exposure; *C* — adjustment is confined to the enamel without increasing the outline form.

6. Isolation of operating field. Dental amalgam is less sensitive to the moisture compared to other restorative materials. Routinely rubber dam is not used. The working field is isolated with cotton rolls and aspiration systems.

7. Pulp protection. In very deep lesions calcium hydroxide cement must first be placed in the deepest parts of such a cavity. This will encourage the formation of reparative dentine and help to remineralize the carious dentine.

As the thermal conductivity of dental amalgam is very high dentinal surface should be covered with a varnish or a liner. An appropriate option is the use of GICs due to their chemical adhesion, good biological and physical properties. Adhesive systems indicated for this purpose (e.g. Optibond FL, Amalgam Bond, One Step, Clearfil Liner Bond 2V, etc.) can also be used.

8. Trituration of the amalgam. Modern dental amalgam is manufactured in preproportioned capsules. Adequate trituration is essential to ensure a plastic mix and thorough amalgamation. The trituration time that is needed is dependent on both the type of the alloy being used, and the dispensing and mixing systems. The sign of a well-mixed amalgam is a shiny, homogeneous mass that adheres together.

9. Amalgam insertion and condensation. Amalgam is placed into the cavity in small portions using amalgam carrier. The most important requirements for the condensation technique are that as much excess mercury should be removed as possible, that the final restoration will be non-porous and that optimum marginal adaptation is achieved. The important components in condensation are the use of maximum force, the use of suitably sized condensers in relation to the cavity size, the use of multiple and rapid thrusts, and the placement of small increments. With spherical alloys small loads should be applied by larger condensers.

10. Carving, occlusion check and burnishing. Amalgam should not be carved until it is sufficiently firm. For adequate carving, it is preferable to overpack the preparation and then carve it to the margins. Carving causes removal of mercury rich surface layer. The carving instruments should have a discoid blade design. The largest instrument is used first, followed by smaller instruments. During carving, movement of the instrument should be parallel to the margin, and the edge of the blade should be perpendicular to the margins, to avoid ditching of the metal and to minimize the overlay.

Occlusion check with articulating paper is done so as to remove any areas left high in the final restoration. Carving is done until the teeth are in their pre-restoration occlusion.

Then burnishing is performed with a suitable size of burnisher to bring the smoothness to shiny appearance. It helps in reducing the surface roughness and improving marginal integrity.

11. Finishing and polishing. This step is usually done at least 24 hours after placement of the amalgam. The most commonly used rotary instruments are tungsten carbide finishing burs, silicone polishers (brown and green), brushes and polishing pastes. Polishing may not be essential for restorations with high-copper alloys because they have a tendency of self-polishing.

RECOMMENDATIONS FOR THE PATIENTS AFTER RESTORATION OF TEETH

Recommendations should be individual, depending on the diagnosis, clinical features, treatment techniques and restorative materials used.

– After local anesthesia it is recommended not to eat until the sensitivity is completely restored.

– Composite restorations should not contact with the colorants (tea, coffee, tobacco, lemonade, red wine, colored juices and berries, lipstick, etc.) within 24 hours.

– A follow-up appointment to check the esthetic restoration is made in 7–10 days.

– After GIC or amalgam restoration the patient should not eat hard food during the first day.

– It's important to re-instruct the patient about individual oral hygiene and define the frequency of preventive visits.

In conclusion, it's worth noting that along with the desire to use new materials and achieve esthetic results, one should not forget that restoration of the tooth is primarily a therapeutic manipulation. The dentists should not underestimate the importance of all technological steps of the work. Furthermore, restoration can only restore the tooth, but does not eliminate the cause of the disease. Therefore, when planning caries treatment, individual prevention should not be neglected.

MODERN PRINCIPLES OF ENDODONTIC TREATMENT

MOTIVATIONAL CHARACTERISTIC OF THE THEME

Total time: 70–90 minutes (seminar).

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

Endodontics is one of the most difficult parts in therapeutic dentistry. Significant difficulties of endodontic treatment are created by a variety of nosological forms of the diseases of pulp and apical periodontium, complexity and variability of anatomy of root canal system, variety of approaches to mechanical and medical root canal preparation and methods of post-endodontic recovery of the tooth.

The correct planning of treatment, knowing and detailed following its basic principles, timely and effective recovery of anatomical tooth integrity are the factors defining to a great extent the success of endodontic treatment.

In recent years plenty of publications dedicated to endodontic treatment have appeared. It was due to the creation of new systems for mechanical preparation of root canals, antimicrobial medicines and materials for obturation of root canal system.

The reasons mentioned above define the necessity to systematize information about the principles and stages of endodontic treatment in this study guide.

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

The tasks of the seminar. The student should know:

– modern principles of diagnosis and treatment of the diseases of pulp and apical periodontium;

– anatomy of pulp cavity and root canal system;

– criteria of efficiency of endodontic treatment.

Requirements for the initial level of knowledge. For full understanding of the topic the student must revise:

– from human anatomy: anatomy of teeth, root canal system, periodontium;

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

– from normal physiology: physiological functions of tooth, pulp and periodontium.

– from pathological physiology: mechanisms of pain occurrence in dental disorders.

Control questions from related disciplines:

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

Control questions for the seminar:

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

PURPOSE, STAGES AND QUALITY STANDARD OF ENDODONTIC TREATMENT

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

Endodontic treatment includes the following stages:

1. Planning.
2. Anesthesia (if necessary).
3. Isolation of the working field.
4. Creation of endodontic access.
5. Determination of working length.
6. Medical and mechanical preparation of root canal system.
7. Verification of working length.
8. Obturation of the root canal system.
9. Restoration of the tooth crown.
10. Long-term control of the results.

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

– All treatment manipulations must be painless.

– Strict following of aseptic and antiseptic rules.

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

– Mechanical and medical preparation and cleaning of root canal are mandatory regardless of the diagnosis (pulpitis, apical periodontitis, etc.).

– During preparation the canal must be enlarged not less than two file sizes, apical part – not less than #25 according to ISO.

– Root canal must be obturated using fillers and sealers.

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

ENDODONTIC TREATMENT PLANNING

The first step of endodontic treatment is diagnosis on the basis of patient's complaints and case history, evaluation of clinical situation and additional examination techniques:

– x-ray;

– temperature test;

– electric pulp test.

X-ray diagnosis refers to additional methods but it is mandatory in all cases of endodontic treatment.

During endodontic treatment 4 x-rays for one tooth are usually made:

– for diagnosis;

– for definition of working length;

– for confirmation of treatment quality;

– for long-term evaluation of treatment quality (6–12 months).

In some cases it's also necessary to control the fitting of gutta percha master point radiologically.

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

Objective part: symptoms of radiolucency and radiopacity in description of dental crown, roots, canals, furcation area, periapical area, preservation of cortical bone, bone volume and bone density.

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

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

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

2. Possibility of precise measurement of anatomic structures.

3. Possibility to study any element of maxillofacial area in any section.

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

The most informative method of X-ray examination during endodontic treatment is long-focused X-ray filming (paralleling technique).

The most popular method of X-ray examination in Belarus is intraoral isometric technique.

Paralleling technique (Fig. 13) is based on a significant distance of X-ray tube from the shot object. In this case the angle of X-ray spreading in projection of the object becomes minimal (parallel ray). It results in good quality x-rays with a minimum of distortion. Film holding devices (XCP — X-tention C-one P-aralleling) provide a superior reference for aiming the x-ray beam and correct film placement so that the tube head is perpendicular to the film.

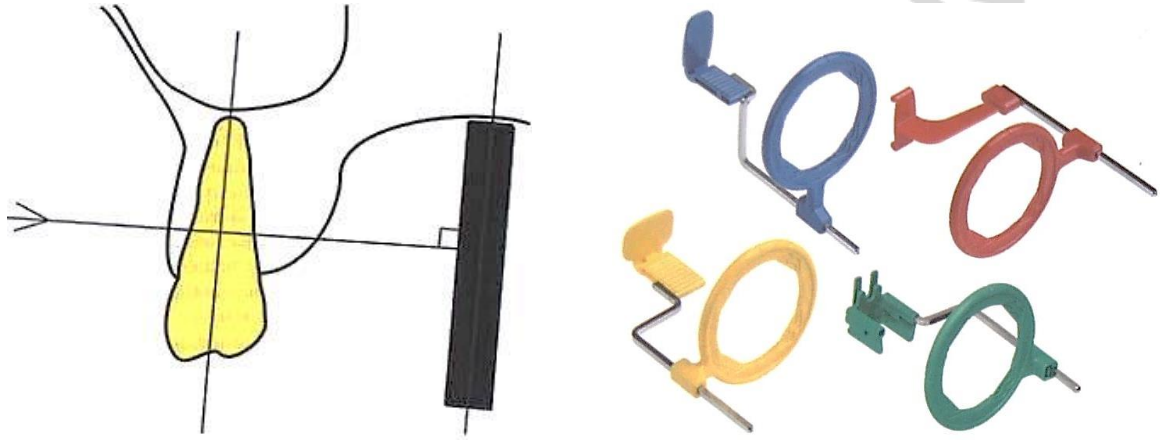


Figure 13. The scheme of paralleling technique and basic types of film holders

In isometric technique (Fig. 14) the ray is directed perpendicularly to bisector of angle between the film and long axis of the tooth.

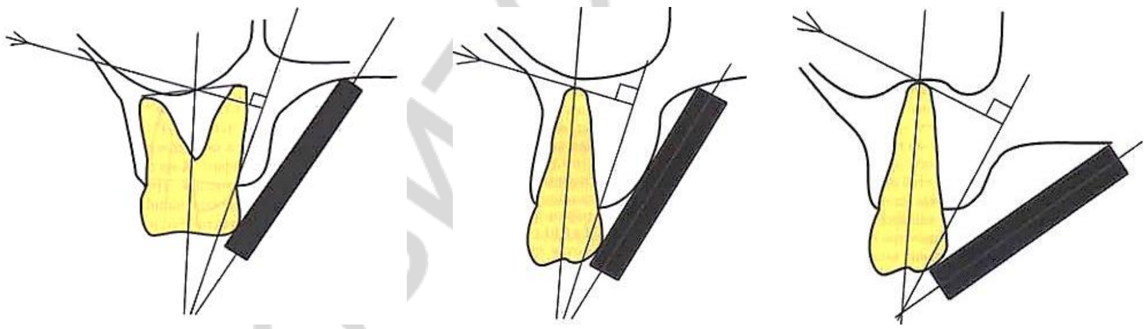


Figure 14. The scheme of intraoral isometric X-ray technique

Note. As X-ray image is a plane image of three-dimensional object, the overlayering of the tooth parts is possible. Exact assessment of dental root is especially difficult at oral and labial position because of their overlayering on each other. For visualization of these tooth parts we can displace the tube head into mesial and distal sides.

Determination of tooth sensitivity to temperature and electric stimulus can inform us about the pulp status. However, as a rule, it is impossible to differentiate the vital pulp from reversible or irreversible pulpitis only with the help of this test as intact nerve tissue can be revealed even in the areas of well-marked necrosis. In some cases sensor tests occur to be positive in the presence of periapical bone destruction (Lin et al., 1984). Nevertheless these tests are known as “vitality tests”.

Cold test is considered to be the most informative. Ice cubes, chloraethyl, frigen (the American equivalent of freon), dry ice (carbon dioxide snow) can be used for this test. According to research of Lutz et al. (1974) application of cold for 4 seconds lowers the temperature of the tooth to 26–30 °C, provoking a painful reaction. The temperature of pulp goes down only by 0.2 °C in this case. The ice cubes provide the temperature about 0 °C, frigen spray applied with cotton pad to the cervical area of the tooth –40 °C, dry ice reaches the temperature –70 °C. Cold test with dry ice has an advantage over the others. Thanks to the isolated layer of steam which is made from this substance at the temperature above 0 °C, this test doesn’t harm the tooth or surrounding tissue. The tooth enamel is not cracked even during 2 minutes of contact with dry ice (Peters et al., 1986).

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

Thus, it is necessary to note that the widely-spread method of tooth sensitivity examination to cold with the help of air or water jet isn’t informative enough. In any case, it’s necessary to remember that cervical area is the most sensitive part of the tooth reacting to cold. The thickness of hard tissues in this area is minimal, therefore the possibility to get an objective response of pulp to the hot stimuli is higher.

Checking of pulp electroexcitability is known as an electric pulp test. It is based on unique relative conduction of hard tooth tissues. The device makes the series of impulses of regulated tension, tuned to resistance of tooth tissue. It is possible to define tooth vitality with electric pulp test. Differential diagnosis of different forms of pulpitis with this test is unlikely. Comparative assessment of pulp electroexcitability of teeth from one anatomical group or from the opposite side is more informative.

Electric pulp test is widely used for dynamic assessment of the pulp status, for example, assessment of pulp vitality after dental trauma.

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

– when anesthesia was made;

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

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

– after recent dental trauma;

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

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

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

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

– at partial pulp necrosis when in some canals the pulp is vital and in others is not;

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

The electric pulp test is forbidden for patients with heart pacemaker.

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

Conservative methods:

– *indirect pulp capping*;

– *direct pulp capping*.

Surgical methods:

– *pulpotomy (vital and devital)*;

– *pulpectomy (vital and devital)*.

When planning endodontic treatment it is necessary to know the factors affecting the successful result:

1. Complexity of treatment.
2. Presence of periapical changes.
3. Knowledge of anatomy.
4. Materials and equipment (including light and magnification).
5. Skills of the operator.
6. Isolation of working field.
7. Quality and depth of preparation.
8. Density of root canal system filling.
9. Hermetic state of restoration.

Complexity of treatment and the presence of periapical changes are the most important success factors (Table 4).

Table 4

Success rates of endodontic treatment

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

Nowadays single visit endodontic treatment is preferable.

Several appointments are needed in the case of MTA usage and visible exudation after mechanical and medical preparation of the root canal system, not enabling to provide dryness and consequently to make permanent filling.

There are also subjective factors defining several visits for endodontic treatment: material (absence of equipment and tools), temporal (lack of time) and operator related (absence of necessary knowledge and skills).

ISOLATION OF WORKING FIELD

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

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

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

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

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

6. Improvement of visual control of manipulations including attention concentration on the object.

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

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

9. Better patient management.

10. Saving time of procedures.

At the same time rubber dam application for endodontic treatment has some disadvantages:

1. Loss of axial landmark on creating endodontic access.
2. Possible injury of oral mucosa.
3. Difficulties of X-ray examination (necessity to remove the frame).
4. Possible allergy.

The technique of four walls which enables to minimize the contact of the root canal system with the oral liquid is an important addition to rubber dam isolation. Nowadays there are several options for this procedure:

– saving of tooth walls;
– preservation of hermetic restorations as the walls;
– temporary restoration with consequent creation of endodontic access;
– application of copper and orthodontic rings;
– temporary crown with consequent creation of endodontic access.

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

Initially glass ionomer cements (GIC) have good marginal adaptation but they are not strong enough and therefore can be used only for short-term restorations in permanent teeth. The use of adhesively cemented composite crowns is possible only for 1–3 months. Metal crowns with plastic covering can be used for 2 years.

CREATION OF ENDODONTIC ACCESS

The basic principle of creation of endodontic access is an excision of all crown tissues which complicate direct access to the root canal orifices.

Stages of endodontic access creation:

1. Preparation of carious cavity (removing old non-hermetic restorations).
2. Pulp cavity trepanation.
3. Pulp cavity opening.
4. Location of root canal orifices.
5. Creation of straight line access.

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

To open the pulp cavity and remove the dentin coves we usually use EndoAccess bur and a cylindrical or conical bur with a rounded non-aggressive tip (Fig. 15).

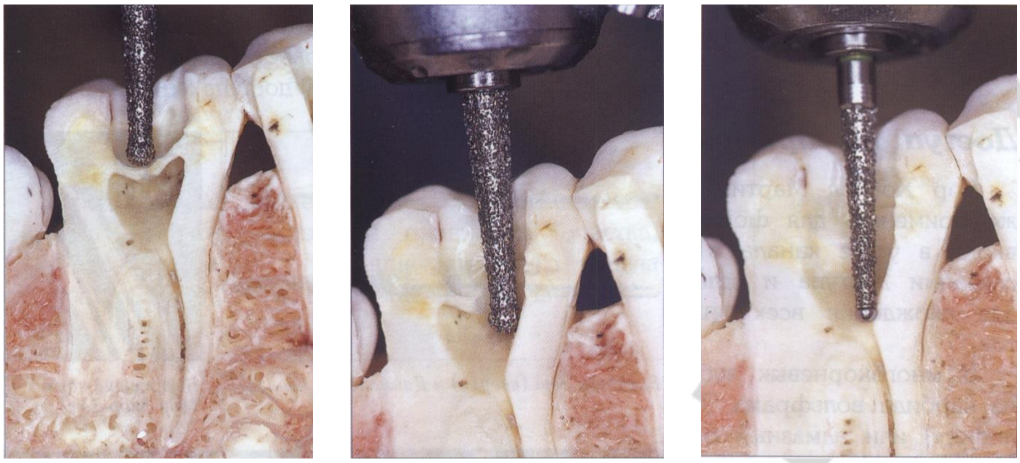


Figure 15. Stages of pulp chamber opening

Complete removal of the pulp roof and dentine coves provides an adequate view of the pulp cavity bottom. The bottom of the pulp cavity has protrusions and depressions where the root canal orifices are located. The location is carried out with a thin hard dental probe or a thin file.

When creating endodontic access it is reasonable to use ultrasonic system (endodontic sets “NSK”, “Satelec”, “StartX” by Dentsply) (Table 5).

Table 5

Indications for Ultrasonic Tip Set StartX

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

Root canals as a rule are curved. Decrease of root canal angle allows creating a straight line access that significantly reduces the possibility of breaking files. Such tools as Protaper SX, Largo, Gates Glidden and X-Gates can be used for root canal angle reduction.

DETERMINATION OF WORKING LENGTH

Determination of working length (distance from the most protruding part of the tooth to physiological constriction) is a particular stage of endodontic treatment. The working length is very variable (Fig. 16).

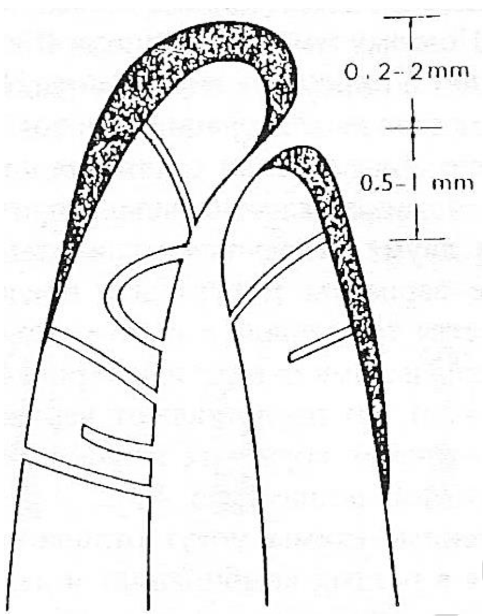


Figure 16. Scheme of root canal apex

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

– prevents traumatizing periapical tissues;

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

– provides optimal depth of canal filling.

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

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

Investigatory:

– diagnostic X-ray;

– tables of average length;

– manual;

– golden ratio.

Verification:

– X-ray with the files;

– physical (apex locators).

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

Combined

The algorithm of working length determination includes 3 steps:

– file insertion to the length 1.5–2 mm less than on diagnostic X-ray;

– verification using apex locator;

– verification using X-ray.

The working length is considered to be determined if the file tip is located 0–2 mm from X-ray apex and the further root canal isn't visible.

MEDICAL AND MECHANICAL PREPARATION OF ROOT CANAL SYSTEM

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

– removal of infected tissues,

– eliminating of microbes,

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

The 2 concepts of canal preparation have been suggested, each of them has some disadvantages (Table 6).

Table 6

Concepts of root canal preparation and their disadvantages

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

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

Rules of medical and mechanical preparation:

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

– Cleaning of files before repeated use in root canal.

– Assessment of file condition before repeated use in root canal.

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

– Returning to the previous file.

– Frequent instillation of root canal system.

– Sufficient exposure and amount of solutions for medical treatment.

“Glide path” technique provides maximum saving of the anatomical canal shape. It is used before preparation with rotary shaping and finishing files and includes consequential use of Pathfile № 1, 2, 3 (Fig. 17).

Creation of glide path is possible using the only tool Proglider which has the tip diameter 0.16 mm (2 %) and increasing taper.

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

– preparation from crown to apex;

– creating conditions for good irrigation;

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

– rotary and manual types of instruments;

– files for retreatment (D1-D3);
– calibrated paper and gutta-percha points.

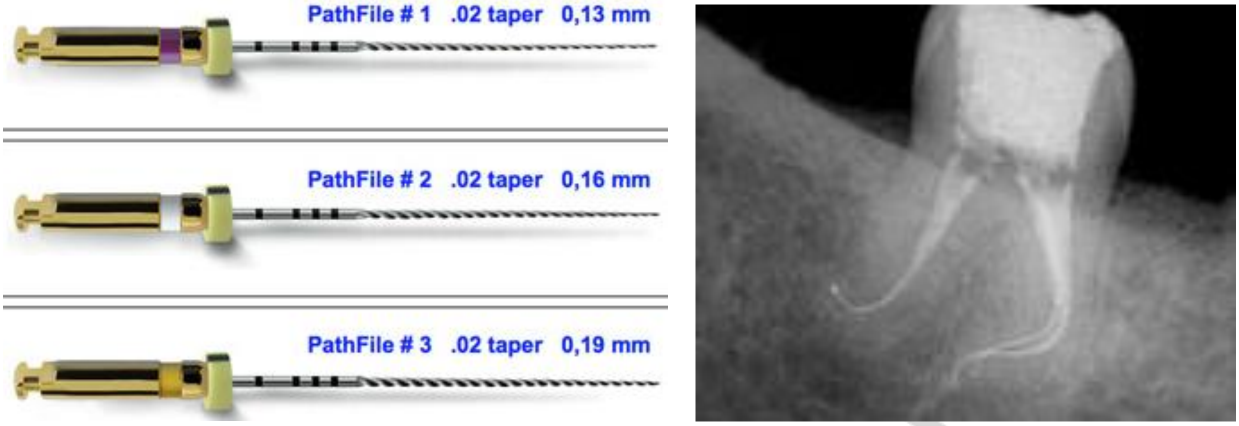


Figure 17. Files for creation of glide path (Pathfiles № 1–3; on the left) and their usage for saving of root canal anatomic shape (Courtesy of Dr. F. Santarcangelo; on the right)

Files of Protaper system for canal treatment (Fig. 18) can be divided into 2 groups:

1) *shaping* (has shape of the Eiffel tower, non-active tip:
SX (apical diameter 19 mm, 4 %),
S1 (apical diameter 18 mm, 2 %),
S2 (apical diameter 20 mm, 4 %),
2) *finishing*, (has the shape of obelisk):
F1 (apical diameter 20 mm, 7 %),
F2 (apical diameter 25 mm, 8 %),
F3 (apical diameter 30 mm, 9 %),
F4 (apical diameter 40 mm, 6 %),
F5 (apical diameter 50 mm, 5 %).

Figure 18. Range of manual Protaper files (SX, S1, S2, F1-F5)

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

1) root canal instrumentation with K-file #10 and #15 and Protaper S1 for 2/3 of length;

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

3) verification of working length;

4) preparation of canal with K-file #10 and #15 and Protaper S1 for entire working length;

5) preparation of canal with Protaper S2 for entire working length;

6) preparation of canal with Protaper F1 for entire working length;

7) in case of apical stop absence — consequential preparation of canal for entire working length with Protapers F2, F3, F4, F5 untill it's formed.

Protaper Next files have the following characteristics:

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

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

– wavy movement of file enlarges cutting efficiency;

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

The system Protaper Next consists of 5 unique files (Fig. 19):

X1 (apical diameter 17 mm, 4 %);

X2 (apical diameter 25 mm, 8 %);

X3 (apical diameter 30 mm, 7.5 %);

X4 (apical diameter 40 mm, 6.5 %);

X5 (apical diameter 50 mm, 6 %).

Figure 19. Protaper Next system files

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

The BioRace system (Fig. 20) has been specifically designed to allow expanding the apical third of the canal without additional preparation steps or instruments. Thanks to the BioRace system, the biological tasks of root canal treatment are solved without sacrificing working efficiency.

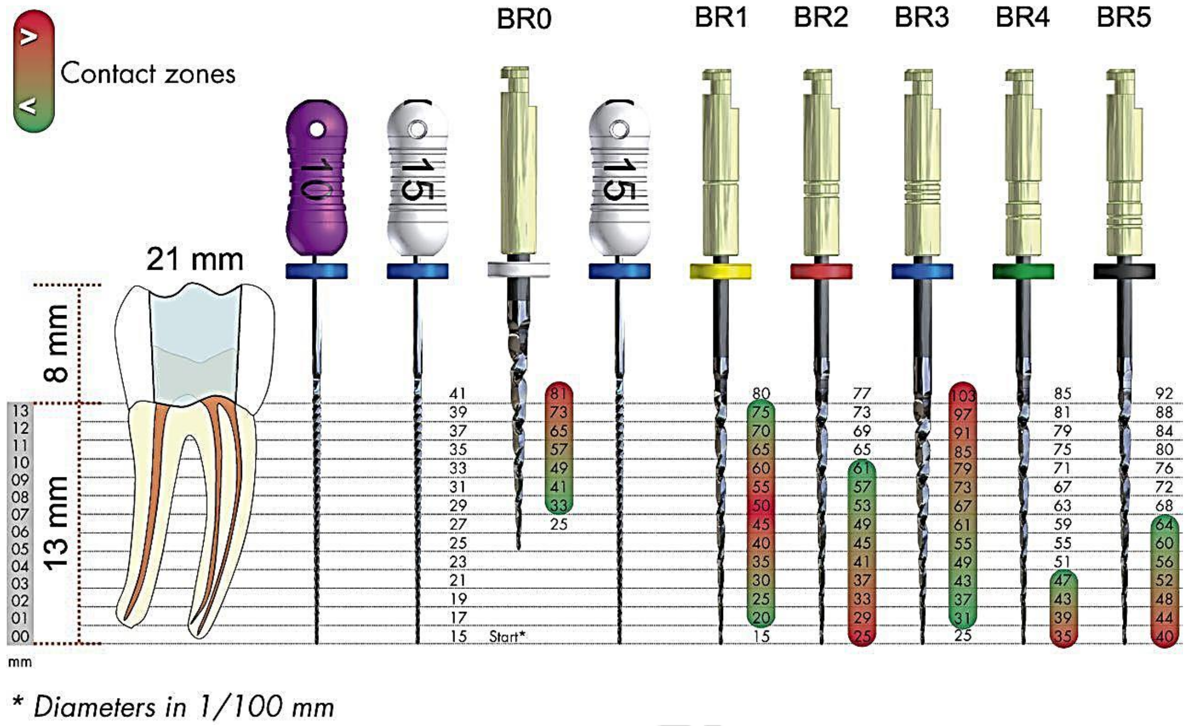


Figure 20. BioRace system files

The BioRace Basic Set is an extremely robust 6-piece system, it contains 6 files: BR0 25/.08, BR1 15/.05, BR2 25/.04, BR3 25/.06, BR4 35/.04, BR5 40/.04 (optional length: 21, 25, 31 mm; recommended speed 600 rpm and torque 1 N·cm).

For canals with significant apical curvature 2 tools are recommended: R4C 35/.02 and BR5C 40/.02. For the most difficult cases, BT-Apisafe, ScoutRace or manual FKG files can be used.

For wide canals 2 tools are recommended: BR6 50/.04 and BR7 60/.02.

The main agents for medical treatment in endodontics are sodium hypochlorite and EDTA (Table 7).

Table 7

Basic agents for medical treatment of root canals system

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

Sodium hypochlorite (concentration not less than 1 %) has proteolytic activity and dissolves pulp and dentin matrix elleviating preparation of root canal mechanically. Moreover, it has a bactericidal effect on a wide range of gram-positive and gram-negative bacteria, fungus and viruses. Oxidation of pigments (formed during pulp necrosis or hemorrhaging) by sodium hypochlorite provides a bleaching effect and makes it effective to correct tooth discoloration.

Concentration of sodium hypochlorite for endodontic purposes varies from 0.5 to 5.25 %. Usage of sodium hypochlorite in high concentration is recommended for pulp cavity and cervical third of canal, usage in low concentration — for apical part of canal especially in case of wide apical opening. Concentration of sodium hypochlorite equal to 3 % is the most universal.

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

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

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

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

Manufacturers often combine EDTA with other active substances:

– quaternary amine (antiseptic) — “Largal Ultra” (“Septodont”);
– hydrogen peroxide (antiseptic, bleaching agent) — “Canal+” (“Septodont”);
– carbamide peroxide (antiseptic, bleaching agent) — “Glyde” (“Septodont”).

The sequence of steps of root canal medical treatment is shown in Fig. 21.

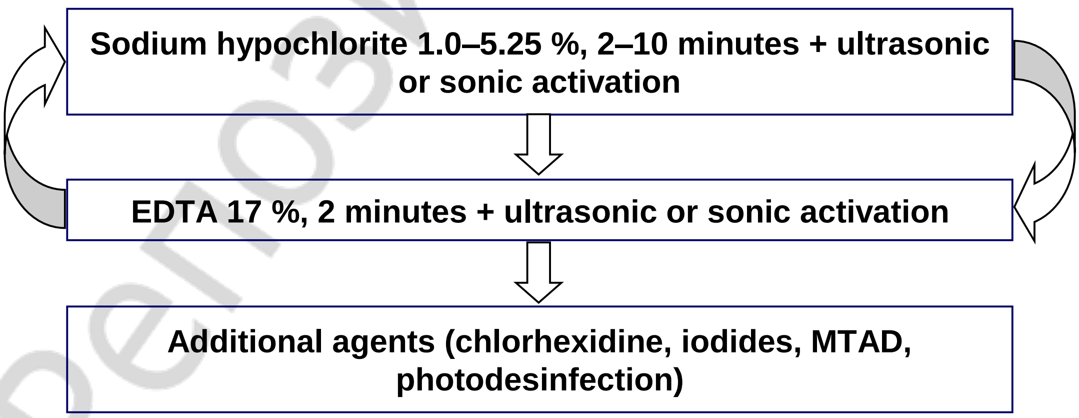


Figure 21. Algorithm of medical treatment of root canal system

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

The main directions to decrease duration of medical treatment are:

– frequent change of agents;
– increasing of the solution volume;
– heating up to 37 °C;
– using of detergents;
– ultrasonic and sonic activation;
– enlargement and conical shaping of the root canal.

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

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

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

– eliminate microbes;
– maintain root canal disinfected between the visits;
– destroy organic remains in root canal;
– lower acidity in the area of inflammation.

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

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

For the temporary filling 2 groups of agents are used:

– agents containing **$Ca(OH)_2$**: “Calcium hydroxide” (“Dental thepapeutics AB”), “Calxyl” (“OCO”), “Calcicur” (“Voco”), “Metapasta” (“Meta”), “Apexdent” (“VladMiVa”);
– agents containing **$Ca(OH)_2$ and iodoform**: “Metapex” (“Meta”), “Apexdent with iodoform” (“VladMiVa”).

There are 3 ways of filling the root canals with calcium hydroxide:

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

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

VERIFICATION OF WORKING LENGTH

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

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

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

OBTURATION OF ROOT CANAL SYSTEM

The tasks for root canal obturation are:

– to disconnect the root canal and the crown part of the pulp cavity;

– to isolate microbial remnants in basic and additional root canals;

– to prevent microleakage into the canal.

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

1. Inactive.
2. Space stable.
3. Doesn't cause allergy.
4. Doesn't stain the dentin.
5. Radiopaque.
6. Compressible.
7. Softens during heating.
8. Softens by organic dissolvers.
9. Removable from root canals if necessary.

There are two types of gutta-percha:

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

2) α-gutta-percha has a low melting temperature, good sticking and viscosity.

Functions of sealer:

– fills microspaces and dentin canals;

– smoothes canal walls;

– provides gliding of gutta-percha points.

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

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

– MTA-based (Filapex);

– silicon-based (RoekoSeal, GuttaFlow);

– glass ionomer cement (Ketac Endo, Endoseal);

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

– containing calcium hydroxide (Sealapex, Apexit);

– dentin adhesive based (Epiphany).

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

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

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

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

1. Cold gutta-percha:
– lateral condensation;
– chemical plastification (eucalyptol).
2. Preheated gutta-percha:
– vertical condensation;
– thermomechanical condensation (ultrasound or gutta-condensor).
3. Thermoplastified gutta-percha:
– injection of gutta-percha (ultrafil);
– core gutta-percha (thermafil, guttacore).

Nowadays the method of lateral condensation is widely used and it has the following steps:

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

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

3. Master point is inserted and pushed laterally with a spreader. The spreader with a stopper is inserted not more than at working length. Then we remove the spreader with ¼ rotatory motions to leave the point inside the canal.

4. Accessory points are inserted into the root canal (preferably with a lager taper — 4, 6, and 8 %), preliminary covered with a sealer. Each of them is condensed as well as the master point. Additional points are inserted until the spreader enter the root canal not more than 2–3 mm.

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

6. X-ray control must be done. If it is not done immediately, the tooth should be temporarily filled.

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

The steps of this technique are the next:

1. Gutta core size verifier is inserted into the canal and rotated 360 degrees at working length.
2. The sealer is applied on the walls of the root canal. The excess of the sealer is removed with paper pin.
3. Gutta-percha is placed into a special oven Thermaprep 2 and heated untill it has liquid consistence.
4. The point is inserted at the working length of the root canal avoiding contacts with its walls.
5. The handle of the obturator is removed by its bending or cutting with a bur or sharp excavator.

RESTORATION OF TOOTH CROWN AND CONTROL OF TREATMENT RESULT

Postendodontic tooth recovery can be done with direct or indirect restoration. High quality restoration provides safety of root filling and defines the treatment result.

Criteria of successful treatment:

– relieving pain and mobility of the tooth (or decreasing these symptoms);
– absence of hyperemia and edema of soft tissue;
– closing of fistula;
– satisfactory tooth restoration;
– full tooth functioning.

Criteria of failed outcome of treatment:

– persisting feeling of pain and increase of tooth mobility;
– hyperemia and edema of soft tissue around the tooth;
– presence of fistula;
– unsatisfactory restoration;
– gentle using of tooth during chewing.

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

Suitable X-ray criteria (Fig. 22):

1. Dense 3D obturation of root canal to the apex.
2. Normal thickness of PDL space (< 1 mm).
3. Presence of reparative processes in periapical area.
4. Intact compact bone of alveolus.
5. Absence of resorption.

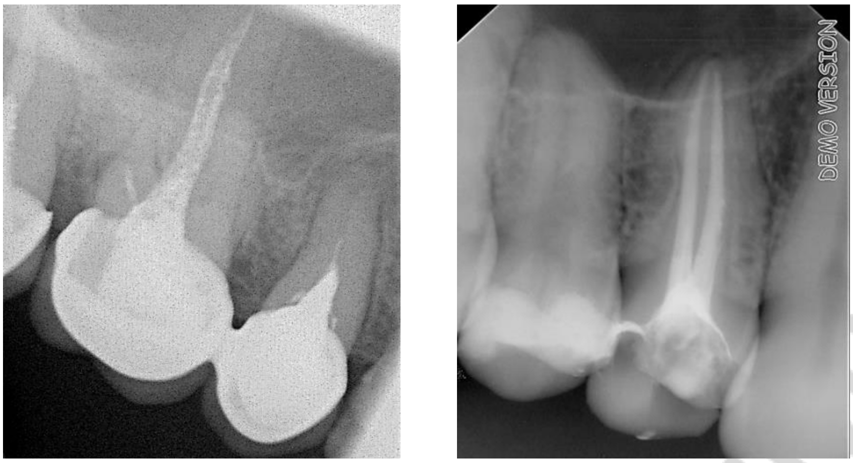


Figure 22. Doubtful (on the left) and suitable (on the right) X-ray criteria of endodontic treatment

Doubtful X-ray criteria:
1. Widening of the PDL space.
2. Absence or insufficient recovery of bone tissue.
3. Destruction of the compact bone.
4. Features of progressive resorption.
5. Emptiness in root filling, especially in apical third.
6. Significant overfilling of the root canal.

ERRORS IN ENDODONTIC TREATMENT AND THEIR COMPLICATIONS

Errors and complications	Causes	What to do?
File breakage	failure of operation technique, loss of working length, file fatigue	To extract the broken file with the help of ultrasound, special systems and “by pass” technique
Perforation of pulp cavity bottom	lack of knowledge about topography of pulp cavity, insufficient endodontic access, poor lightning	To close perforation with MTA or ZOE-cements
Perforation of root wall	failure in operation technique, using of rigid files in curved canals	To close perforation with MTA
Transportation of apex	using of rigid files in curved canals, loss of the working length	To use flexible files and to create an apical stop
Canal obturation with debris	insufficient instillation	To use more volume of solutions, endodontic needles and to use recapitulation
Stripping*	aggressive mechanical preparation (usually using rigid files)	To provide rational postendodontic restoration of the tooth
Creation of the ledge in canal (including zipping)	using rigid files in curved canals, loss of working length	To eliminate the ledge using flexible files and microscope
Overfilling of the root canal	loss of working length, aggressive insertion of sealer	To supervise (if no pain)

Errors and complications	Causes	What to do?
Pain after filling the root canal system	loss of working length and pushing infected tissue through the apex, overfilling	To supervise, prescribe non-steroid anti-inflammatory drugs, laser therapy
Tooth fracture	excessive preparation, inadequate postendodontic recovery	To use post and crown (if possible) or to extract the tooth
Appearing or progressing of periapical lesion	insufficient medical or mechanical treatment, loss of the working length and pushing infected tissue through the apex	To repeat endodontic treatment

* Stripping is an excessive widening of canal in the middle third along the small curvature.

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CONTENTS

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