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КАФЕДРА ТЕРАПЕВТИЧЕСКОЙ СТОМАТОЛОГИИ С КУРСОМ ФПК И ПК

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Therapeutic Dentistryf or the 3rd year student

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PREFACE

This educational and methodical edition is based on the Educational program of the higher educational establishment on academic discipline for 1-79 01 07 “Stomatology” specialty. It is intended for 3rd year students of the Stomatological Faculty studying therapeutic dentistry in English.

It contains two sections - 5th semester and 6th semester.

The 5th semester contains educational material for 19 lessons. This section discusses the issues of antiseptics and sterilization in dentistry, individual and professional hygiene, cariesology, non-carious lesions. Materials for this part were previously published in «Guideline on therapeutic dentistry for the 5-th term» (2016). In the new edition, some of the topics have been revised and supplemented. Added new topics, such as «Methods of investigation characterized destructive process of periodontal tissues», «Possibilities of filling material choice in different cases», «Minimal invasive methods of operative treatment of dental caries».

In the 6th semester, theoretical aspects of pulp and periodontal disease, some issues of materials science, the main stages of endodontic treatment are covered in detail. This section presents material for 16 lessons.

The edition complements the existing educational literature on therapeutic dentistry.

6 SEMESTER

LESSON 1.ISOLATION MATERIALS FOR PULP

The questions to be studied for the learning of the topic:

1. Preparations for the treatment of dental pulp hyperemia. Classification.
2. Materials based on calcium hydroxide.
3. Varnishes are based on calcium hydroxide. The composition and properties.
4. The calcium-containing chemical curing cements.
5. Light-curing resin material containing calcium hydroxide.
6. Mineral trioxide aggregate (MTA). Composition. Properties.
7. Zincoxide - eugenol cement.
8. The adhesive system.

Question 1. Drugs for treatment of dental pulp hyperemia. Classification.

Treatment of pulp hyperemia is aimed at restoring its basic functions, maintaining a full structure of hard tissues of the tooth.

Preparations for the treatment of redness of the pulp must meet a number of requirements: to be ductile to withstand the pressure after curing, have good adhesion to the tooth structure, antibacterial properties, does not irritate the pulp of a tooth to stimulate reparative function, optimize softened dentin remineralization.

In the treatment of deep caries the pulp chamber remains unopened and no clinical signs of degenerative changes in the pulp and periapical tissues. This technology is used indirect therapeutic interventions to stimulate natural defense mechanisms against the pulp cavities to form reparative dentin.

When dissection cavity or a traumatic fracture of the tooth pulp exposure may occur, and this requires selecting the optimal method of treatment. The thickness of the mineralized tooth tissue varies depending on the size of the tooth. The physician must be familiar with the anatomy of the teeth to prevent careless opening of the pulp chamber and pulp exposure. It is known that the thickness of hard tissue to enamel-dentin border in the cervical region of the central lower incisor varies between 1.2 -2.1 mm, the upper first premolar: 2.2-3 mm, molar: 2.7-3.4 mm. To prevent pulp exposure are encouraged to gradually removing carious dentin.

In the indirect method of treating pulp all layers of dentin caries are removed. As a result, it is disappearing substrate on which bacteria could produce acid. This removes most of the bacteria. The pulp is exposed to when the carious process is developing faster than the action mechanism of

reparative pulp. With stop caries process reparative mechanism is able to form additional dentine and prevent exposure of the pulp. It is found that after the removal of the infected dentin number of microorganisms is reduced significantly if the remaining dentin layer coated tsinkoksidevgenolovoy paste or calcium hydroxide.

Thus, in case of accidental opening of the cavity of the tooth and deep caries (tooth cavity without opening) we need the use of therapeutic agents for direct or indirect pulp capping. There are several groups of materials:

Materials are containing Ca (OH). They are:

1. Clean powder and an aqueous suspension of calcium hydroxide: Kalradent (VladMiVa), Calasept (Nordiska Dental), Calcium Hydroxide (SPAD / Dentsply), Calcicur (Voco), Calcipulpe (Septodont), Calcium Hydroxide (Septodont).
2. Varnishes by calcium hydroxide: Contrasil (Septodont), Kaltsetat (VladMiVa).
3. Calcium-containing. Dental chemical composites: Kaltsesil (VladMiVa), Alkaliner (3MESPE), Dycal (DeTrey / Dentsply), Life (Kerr), Calcimol (Voco), Septocalcine Ultra (Septodont), Reocap (Vivadent), Rado-layer (Rainbow - R).
4. Light-curing polymer materials containing calcium hydroxide Kaltsesil LC (VladMiVa) Esterfil Ca (Diaz), Calcimol LC (Voco).

Question 2. Materials are based on calcium hydroxide.

A powder of calcium hydroxide used has a high pH (11-12,5). It is most effective in the treatment of pulp hyperemia (direct coating), but it dissolves over time. This is related to the need for the drug every 1 - 1.5 months, and the duration of treatment of hyperemia of the pulp can be from 3 to 9 months.

The slurry is a mixture of pure powder of Ca (OH) with water or saline solution. Manufacturers add for the convenience of work thickener and barium sulfate for radiocontrast. This is due to the complexity of using an aqueous solution of calcium hydroxide.

Question 3. Varnishes are based on calcium hydroxide. The composition and properties.

Varnishes reliably protect the pulp from the acid treatment of dental cements, however, they are not compatible with the composite material as the violated polymerization process, and the residual monomer destroys composite film of varnish.

Varnishes are fast drying compositions composed of calcium hydroxide, zinc oxide, a resin and a solvent (chloroform).

Several authors noted that the characteristic of this group of drugs are low efficiency and uncomfortable to use. Currently, lacquers based on calcium hydroxide as therapeutic spacers are not used and their main application - covering vital teeth, under the prepared cermet crown. Varnish is applied with a brush or a sterile cotton swab.

Question4. Calcium-containing chemical curing cements.

This group of cements are the most common and most popular group of materials in modern dental practice.

The composition and properties. Cements are usually a system of paste / paste and harden after mixing (pH = 10-11).

Hardening calcium-containing drugs are less effective compared to pure calcium hydroxide, as they have less pronounced alkaline properties and can not cause the desired aseptic necrosis of the surface layer of pulp. The method works.

Question 5. Light-curing polymeric materials containing calcium hydroxide.

The composition and properties. These drugs are composed of calcium hydroxide, a radiopaque filler, and light-curing resin. Despite the increased mechanical strength and ease of application, a broad application in dentistry are not found due to inadequate long period of release of ions and calcium hydroxide - just prior to polymerization of the material.

Question 6. Mineral trioxide aggregate (MTA). Composition. Properties.

MTA (Mineral Trioxide Aggregate) having the ability to enhance tissue regeneration along with good pulpal response and almost no tissue reaction or damage proves itself as the most versatile material in our field of dentistry. Its of very importance in the obturation of root canal system in endodontics and also in the field of pediatric dentistry in management of non vital immature teeth, apexification. Also proves itself in dentine bridge formation. So, MTA needs to the explosed more and more by clinicians so as to use it upto its best and its beneficial properties can be extracted.

Properties of MTA

1. ***Compressive Strength***. It takes an average of three to four hrs for the MTA to completely solidify. It is shown that once it is set, it has compressive strength equal to IRM and super EBA but less than amalgam.
2. ***Radio-opacity.*** MTA is less radio-opaque than IRM, super EBA, amalgam or gutta percha and has similar radiodensity as zinc oxide Eugenol. The mean radioopacity of MTA is 7.17 mm of equivalent

thickness of aluminium, which is sufficient to make it easy to visualize radiographically.

3. ***Solubility :*** Set MTA shows no signs of solubility, the solubility might increase if more water is used. The set MTA when exposed to water releases calcium hydroxide which might be responsible for its cementogenesis inducing property.
4. ***Marginal adaptability & sealing ability***. This property is most vital for any restorative material when it is to be for root end filling, repair of perforations, pulpcapping or pulpotomy procedures. Bates et al found MTA superior to the other root and filling materials. MTA has excellent sealing ability due to its property to expand. MTA also proved itself to be superior in the bacterial leakage list by not allowing the entry of bacteria at the interface. MTA of thickness of about 4 mm is sufficient to provide a good seal.
5. ***Antibacterial and antifungal properties***. Due to the property of MTA to provide good seal and preventing microleakage it can be proclaimed anti bacterial agent against Enterococcus faecalis and streptococcus sanguis in vitro. MTA does not show anti microbial activity against anaerobes but shows some against 5 (S mitis, S mutans, S salivarius, S epidermis and Lactobacillus) of the nine facultative bacteria.
6. ***Tissue Regeneration***. MTA is capable of activation of cementoblasts and production of cementum. It allows for overgrowth of cementum and also facilitates regeneration of PDL. Also allows bone healing and eliminates clinical symptoms in many cases.
7. ***Mineralization***. MTA just as calcium hydroxide induces dentine bridge formation. Holland et al found calcite crystals nearest to the opening of the dentinal tubules close to MTA. They theorized that the tricalcium oxide in MTA reacts with tissue fluids to form calcium hydroxide resulting in hard tissue formation in a manner similar to that of calcium hydroxide.
8. But the dentine bridge formed with MTA is faster, with good structural integrity and more complete that with calcium hydroxide.
9. ***Reaction with Other Dental Materials.*** MTA does not react or interfere with any other restorative material.
10. ***Biocompatibility***. Kettering and Torabinejad studied MTA in detail and found that it is not mutagenic and is much less cytotoxic as compared to super EBA and IRM.

Genotoxicity tests of cells after treatment of peripheral lymphocytes with MTA showed no DNA damage.

Arens and Torabinejad reported osseous repair of furcation, perforations treated with MTA.

MTA showed good interaction with bone forming cells, cells remained viable and released collagen even after 72 hours with good adherence

Historical Perspective

MTA was first introduced in the dental literature in 1993 and received Food and Drug Administration (FDA) approval in 1998. In 1999 ProRoot® MTA was the first commercially available MTA product to be launched in the United States. MTA Angelus® (was launched in Brazil in 2001 and received FDA approval in 2011, making it available in the United States. (Author's note: A new product said to be comparable to MTA Angelus is Endocem MTA, which is manufactured in South Korea by Maruchi Co. Ltd. The author is not aware of it being available in North America or of any research on it done in North America.) MTA Angelus exhibits a reduced setting time, is sold in containers that permit more controlled dispensing, and possesses the same desirable properties as traditional MTA. While the original MTA product is sold in single-use packets, the newer MTA Angelus is packaged in air-tight bottles that allow practitioners to dispense a small volume of powder and reseal the remainder of the product in its original container for future use. Traditional MTA takes about 2 to 3 hours to set. MTA Angelus sets within 15 minutes of being prepared. The decreased setting time is sometimes desirable as clinicians can ensure the material is set at the time of placement and can proceed with their restorative procedures without being concerned about MTA washout. This reduced setting time is a result of a lower concentration of calcium sulfate, which is the substance responsible for the longer setting time in the original formulation.

MTA comes in grey and white versions. The first MTA products were grey, and most of the initial research was done on this formulation. Due to staining concerns that were reported when MTA residues were left in the clinical crown, the white version of MTA was introduced to the market in 2002. White MTA has shown a decreased potential for staining but clinicians should still be diligent in removing all traces of it prior to restoring the coronal access of teeth in the esthetic zone.14 The difference between the two colors is mostly due to a decrease in the concentrations of iron, aluminum, and magnesium oxides in white MTA. The major difference is in the relative proportion of iron oxide where white MTA was found to have 90.8% less when compared to the original grey MTA variety. Even with these modifications, white MTA still possesses similar properties to grey MTA cement. When first introduced, clinicians had difficulty handling MTA due to its wet sandlike consistency, which was unlike most other conventional dental materials. Following the introduction of several customized application devices, the handling and application of this material has become more predictable.

One of the indications for the use of MTA is direct pulp capping (for example, in the case of traumatic pulpitis), vital amputation.

Pulp Capping. Pulpal exposures are sometimes inevitable when addressing large carious lesions. While some clinicians are hesitant to perform direct pulp capping procedures due to documented unpredictability as a definitive treatment option, MTA may help to improve the outcome of this treatment in the near future. MTA has the advantage of being less soluble than calcium hydroxide and offers an enhanced seal due to its setting expansion, which hermetically seals the pulp space, preventing bacterial contamination from the outside. Studies have shown that in asymptomatic cases or in cases with reversible pulpitis (where the infection has not spread into the pulp chamber proper), MTA pulp capping can serve as a viable treatment option. Histological studies have also shown less inflammation and more dentinal bridging when MTA is placed compared to conventional pulp capping with calcium hydroxide. In pulp capping, the rapid 15-minute set of MTA Angelus allows the final restoration to be placed without delay and in direct contact with the set MTA.

Vital Pulp Therapy. In cases of irreversible pulpitis where bacteria have invaded the pulp chamber, a pulpotomy procedure can sometimes be considered. This procedure is also termed apexogenesis because its ultimate goal is to facilitate the complete formation of the apex and root. This procedure is carried out in immature teeth with incomplete root formation that contain vital pulp tissue. The radicular pulp, which is considered to be relatively free of inflammation, is retained. When this is done, at a histological level odontoblasts will differentiate, dentin will continue to be laid down, and root development should continue. This will result in thickening of the root walls, which reduces the risk of root fracture, and apical closure should occur (apexogenesis), forming a natural apical constriction that would facilitate any future root canal obturation procedures. ***Clinical procedure***: Once in the pulp chamber, clinicians should use a diamond bur, because it will cauterize the tissue and minimize the bleeding. After this is done, the area should be disinfected with an antimicrobial agent (sodium hypochlorite or chlorhexidine), followed by a saline rinse. Hemostasis is obtained with light pressure from a damp cotton pellet. The pellet is removed after 2 or 3 minutes, and the area is then ready to be filled with MTA.

Question 7. Zincoxide - eugenol cement.

Representatives Evgetsent (VladMiVa), Zinoment (VOCO), IRM (Dentsply), Cavitec (Kerr).

The composition and properties. The basis of these cements are zinc oxide and eugenol or clove purified oil.

Among the positive properties of the drug should be noted:

- ✓ Antiseptic. According to some researchers zinc oxide eugenol retards the growth of microorganisms.
- ✓ The sealing ability.

Negative properties:

- ✓ It is an acute inflammatory reaction when applied directly to TSETS pulp. This is due to the fact that the phenol derivative is eugenol and direct pulp capping blood vessels causes thrombosis. Subsequently develops a chronic inflammation that ultimately leads to necrosis of the pulp.
- ✓ inhibits the polymerization reaction of composite materials.

As a therapeutic pad zincoxide - eugenol cement can only be used for indirect pulp capping.

Question 8. The adhesive system.

The most controversial is the view regarding the direct pulp capping using adhesive systems of different generations.

On the one hand, some researchers have expressed support for the direct coating nude pulp adhesives, as healing is directly related to the ability of the filling material to provide a sealed protection against bacteria. Recovery of pulp aseptically occurs regardless of the filling material.

On the other hand, there is the low efficiency of adhesive systems and a poor prognosis for direct coating. There is a problem of infection of the surface layer of the pulp, as adhesives, in contrast to calcium hydroxide and MTA not cause avascular necrosis of the surface and do not possess antibacterial activity.

Thus, the most effective drugs for direct pulp capping is a pure calcium hydroxide and MTA. To cover the indirect approach pure Ca (OH), calcium-containing chemical curing agents and zincoxide - eugenol cements.

Tests to the topic

1. Which material you choose for the healing liners under hyperemia of the pulp (deep caries)?

a. Zincoxide - eugenol cement.
b. Ionoseal (glass ionomer cement).
c. Dyract (compomer).
d. Akvadent ((glass ionomer cement).
e. Dycal (Ca - containing cement).

2. Specify the pH treatment healing liners:

a. 7.8.
b. 12.4.
c. 8.2.

d. 5.
e. 5.5.

3. What effect has adhesive system?

a. Protective.
b. To improve fixing composites.
c. Odontoplastic.
d. Anticaries.
e. Anti-inflammatory.

4. The basic requirement for materials for healing liners are:

a. To provide a seal to be dentin and contribute odontotrophic and antiseptic effect.
b. To provide anti-inflammatory, antimicrobial, odontotrophic action.
c. Irritate the dental pulp.
d. Provide anticaries effect.
e. Only provide antimicrobial action.

5. Drugs that have an odontotropic effect are:

a. Sulfonamides.
b. Calcium hydroxide.
c. F-containing.
d. Corticosteroids.
e. Eugenol.

6. Drugs which relieve pain better and contribute to the alleviation of the inflammatory response while maintaining the vitality of the pulp are:

a. Antibiotics.
b. Calcium hydroxide.
c. Corticosteroids.
d. Eugenol.
e. Iodine.

7. The preparation of the cavity edges is carried out:

a. To remove all modified dentin.
b. By diamond burs (with a red stripe, 40 microns).
c. To increase the adhesion area.
d. To create good access to all areas of the cavity and its observation.
e. For more efficient etching.
f. By ball-shaped carbide burs.

8. Medical treatment of the cavity allows:

a. To reduce the number of pathogenic bacteria in parietal dentin.
b. To reduce the risk of "postoperative" sensitivity.
c. To prevent inflammatory complications from the dental pulp.
d. To achieve good fixation of the filling.
e. To remove all modified dentin by chemical means.

9. During the formation of a carious cavity, it is necessary to ensure:

a. Convenient instrumental treatment of the cavity.
b. Convenient insertion of filling material.
c. Retention.
d. Resistance.
e. All of the above.

10. The main goals of drug treatment of carious cavities are:

a. Cavity cleaning from dentin sawdust, oral fluid and other contaminants.
b. Bactericidal effect on the microflora in the cavity.
c. Bactericidal effect on microflora in parietal dentin.
d. Cavity drying.
e. All of the above.

LESSON 2.CLINICAL AMALGAM APPLICATIONS IN THE RESTORATION OF TEETH

The questions to be studied for the learning of the topic:

1. Amalgam: definition, history of creation, chemical composition. Amalgam that does not contain the γ-2 phase.
2. Classification of dental amalgam.
3. Properties of amalgams.
4. Indications and contraindications to the use of amalgam.
5. Features of the preparation of cavities for amalgam.
6. The method works with amalgam.
7. Safety precautions when working with amalgam.

Question 1. Amalgam: definition, history of creation, chemical composition. Amalgam that does not contain the γ-2 phase.

Amalgam is one of the oldest filling materials in dentistry. It's the standard for comparison with modern filling materials.

Dental amalgam is a metal-like restorative material composed of a mixture of silver/tin/copper alloy and mercury. It's is one of the most universal restorative materials used in dentistry. It constitutes approximately 75% of all restorative materials used by dentists. It has served as a dental restoration for more than 165 years. There is still no adequate economic alternative for dental amalgam. The combination of reliable long-term performance in load bearing situations, and low cost is unmatched by other dental restorative material. It has a myriad of uses: rather low technique sensitivity, self-sealing property and its longevity.

Traditional amalgam is a kind of amalgam, up to 95% of the powder of which is silver with tin, which after hardening contains the γ2-phase.

Amalgam was introduced to the United States in the 1830s. Initially, amalgam restorations were made by dentists filing silver coins and mixing the filings with mercury, creating a putty-like mass that was placed into the defective tooth. As knowledge increased and research intensified, major advancements in the formulation and use of amalgam occurred. Concerns about mercury toxicity in the use of amalgam were, however, expressed in many countries; concerns reached major proportions in the early 1990s. The American Dental Association (ADA) and the U.S. Public Health Service have issued many statements expressing their support for the use and safety of amalgam as a restorative material.

Initially, the amalgam contained no less than 65% silver, no more than 6% copper, 29% tin, 2% zinc. The composition, advantages and disadvantages of amalgams today are presented in the tables.

Table1.**Composition and characteristics of amalgam elements**

Chemical element	Advantages	Disadvantages
Silver (Ag)	Durability. Corrosion protection.	Causes volume expansion of the amalgam
Tin (Sn)	Slows down the hardening of amalgam Increases plasticity.	Reduces strength
Copper (Cu)	Gives strength Base of corrosion protection, Gives antibacterial properties	Increases volumetric expansion Curing is faster
Zinc (Zn)	Increases mercury wettability of components during alloy preparation	
Mercury (Hg)	It is actually the main agent causing a chemical reaction.	When the amount is increased more than necessary, it reduces strength and causes toxic and allergic reactions

Table 2. **Amalgam properties depending on particle shape**

Particle shape	Advantages	Disadvantages
Cuttings	Increases amalgam density and edge adhesion.	Increases the amount of mercury required for wetting Have a large volumetric expansion
Spherical particle	Decreases particle density and edge adhesion. Decreases volumetric expansion	Decreases mass ratio of mercury to achieve working condition
Mixture in different proportions of the first and second	Properties, respectively, depend on the ratio of the number of components in the powder	

There are two types of amalgams: low- copper amalgam (65 % silver, 25 % tin, ***less than 6 % copper*** and sometimes 1 % zinc.), high-copper amalgam (40–60 % silver, 27–30 % tin, ***13–30 % copper*** and 1 % zinc).

Low- copper amalgams react as follows:

$$\underset{(\gamma)}{Ag_3Sn} + Hg \rightarrow \underset{(\gamma_1)}{Ag_2Hg_3} + \underset{(\gamma_2)}{Sn_{7\text{-}8}Hg_3} + \underset{(\gamma)}{Ag_3Sn}.$$

For high copper alloys, the reaction is different. It occurs in two phases. The initial reaction is similar in that of low copper alloys, i. e.

$$\underset{(\gamma)}{Ag_3Sn} + \underset{eutectic}{Ag\text{-}Cu} + Hg \rightarrow \underset{(\gamma_1)}{Ag_2Hg_3} + \underset{(\gamma_2)}{Sn_{7\text{-}8}Hg_3} + \underset{(\gamma)}{Ag_3Sn} + \underset{unreached}{Ag\text{-}Cu}$$

The second phase of the reaction involves the silver copper phase (Ag-Cu). It reacts with (Ag3Sn) and mercury to form Ag_2Hg_3, $Sn_{7\text{-}8}Hg$ and Cu_6Sn_5 phase. The mercury released from Sn7-8Hg (γ 2 phase) reacts with silver to form Ag_2Hg_3 (γ1) phase.

$$\underset{(\gamma_2)}{Sn_{7\text{-}8}Hg} + \underset{eutectic}{Ag\text{-}Cu} \rightarrow \underset{(\eta)}{Cu_6Sn_5} + \underset{(\gamma_1)}{Ag_2Hg_3} + Ag\text{-}Cu$$

This reaction goes on. After one week, the 2 phase reacts completely with eutectic and replaces all the γ2 phase by and γ1 phase.

The amalgam components that have reacted with mercury form the so-called amalgam phases. Phases coexist all together in the composition of hardened amalgam. Each phase has its own specific properties (see table).

Table 3. **Amalgam phase properties**

Reaction phases	Chemical composition	Properties
γ	Ag_3Sn	Very stable and strong mixture
γ-1	Ag_2Hg_3	Quite strong and resistant mixture to corrosion
γ-2	Sn_7Hg	Substance unstable to corrosion with reduced strength and increased volumetric expansion
ε	Cu_6Sn_5	Has antiseptic properties and abrasion resistance

The γ-2 phase is practically not formed in high-copper compositions, since copper binds the tin included in the amalgam. Correspondingly, the corrosion resistance and strength of the amalgam are sharply increased. Therefore, most manufacturers are striving to produce the so-called amalgam that does not contain the γ-2 phase now.

Amalgam that does not contain the γ-2 phase.

Modern amalgam is a kind of amalgam that, due to the higher copper content after solidification does not contain the γ2-phase. *Synonyms*: amalgam with high copper content, amalgam without γ2-phase, non-γ-2 amalgam, γ-2-free (non-γ-2).

The use of modern amalgams began in 1968 in Canada, when the Disperalloy amalgam with a high copper content without γ2-phase was used for the first time in clinical practice. The composition of modern amalgam without gamma-2 is characterized by a high content of copper (up to 12-30%) and silver (up to 30-40%). These amalgams and traditional amalgams are very similar. Their positive and negative qualities are also similar.

Clinical features of modern amalgams:

1) a wide range of amalgams from different manufacturers;
2) the choice of the type and size of powder particles, depending on the preferences of the dentist;
3) choice of working hours amalgams: slow-setting, fast-setting, standard;
4) a range of capsules with different powder volumes minimizes amalgam waste;
5) higher initial strength - less chips;
6) modern amalgams stain tooth tissues much less. More aesthetic due to greater corrosion resistance and the addition of a number of chemical elements (indium, vanadium);
7) different techniques for working with amalgam are available;
8) methods of finishing in 1 and 2 visits are available;
9) release of amalgams only in standardized capsule form with color or digital coding.

Modern amalgams, despite a number of disadvantages and strong competition from composite materials, have a quite wide range of clinical indications and can be used:

1) for the treatment of carious defects of classes I and II of medium and large size in permanent teeth, including in areas exposed to a large chewing load;
2) for the treatment of cavities of the V class of molars and premolars in the absence of high aesthetic requirements;
3) as a material for restoring the stump of a tooth for artificial metal and metal-ceramic crowns;
4) in patients with poor hygiene;
5) in cases when control of the dryness of the working field is difficult or impossible;
6) in cases where the price is a determining factor in the choice of filling material.

Clinical contraindications for the use of modern amalgams:

1) allergic to mercury or any metal contained in the powder;
2) clinical cases in the areas visible with a smile, when the main requirement is high aesthetics of the restorations.

Question2. Classification of dental amalgam

1. Number of alloyed metal:

- ✓ Binary alloy (Ag- Sn)
- ✓ Tertiary alloy (Ag- Sn- Cu)
- ✓ Quarternary alloy(Ag- Sn- Cu- Zn)

2. According to the shape of powdered particle:

- ✓ Lathe-cut;
- ✓ Spherical;
- ✓ Admixed.

Lathe-cut alloys are irregular in shape; they may be fine-grain or coarse-grain. They are heat-treated to produce a uniform composition and regulate properties. The alloy may be dispensed in the form of preweighed tablets or pellets.

Spherical alloys cure alloy particles made in the form of small spheres. One method of preparing this is known as atomizing procedure. Spherical alloys amalgamate very readily. Amalgamation can be accomplished with smaller amount of mercury than that required for lathe-cut alloys.

Table 4. **Differences between Lathe-cut and Spherical alloys**

Lathe-cut	**Spherical**
More mercury (50 %)	Less mercury (42 %)
More condensation force	Less condensation force
Neededsmaller condenser points	Neededbroader condenser points
Less ease in carving and burnishing	Smooth surface during carving & burnishing
Less overhangs and strong proximal contacts	Overhangs and weak proximal contacts

3. According to zinc content:

- ✓ Zinc containing alloy (> 0.01–2 %);
- ✓ Non zinc containing alloy (< 0–0.01 %).

4. According to copper content:

- ✓ Low copper amalgam(< 0–6 %);
- ✓ High copper amalgam(> 6–13 %).

Generations of dental amalgam:

- ✓ Class – I Silver and tin in ratio (8:1).
- ✓ Class – II Silver, tin, copper (4 %), zinc.
- ✓ Class – III Silver eutectic alloy added to original alloy.
- ✓ Class – IV Copper content increased to 29 %.
- ✓ Class – V Indium added to mixture of silver, tin and copper.
- ✓ Class – VI Noble metals added such as palladium.

Question3. Properties amalgams

Amalgam has both positive and negative characteristics.

On the positive properties of the amalgam should include the following:

1. High mechanical strength;
2. Resistance to abrasion;
3. Long service life (30 years);
4. Plasticity;
5. Enough good manipulation properties;
6. Resistance to dissolution in the oral fluid;
7. Not a bad polishing;
8. The relatively low cost.

Negative properties amalgams:

1. High thermal conductivity;
2. The absence of chemical adhesion to hard tissues of the tooth;
3. High thermal expansion coefficient does not match that of the hard tissues of the tooth;
4. A large percentage of shrinkage that worsens marginal integrity seals
5. Non-compliance by the color of hard tissues of the tooth;
6. Toxicity;
7. Source galvanic effects in the oral cavity;
8. Can lead to amalgamation of gold dentures in the mouth.

Question4. Indications and contraindications to the use of amalgams.

Indications for use of amalgam fillings:

A. Filling cavities 1 and Class 2
B. Filling of cavities class 5 on the molars and premolars
C. Filling subgingival cavities molar
D. The cavities in the teeth that come under the coverage of crowns
E. Retrograde filling of root tip during resection of root apex

Contraindications to the use of amalgams are:

1. Chronic mercury intoxication.
2. Allergic reactions to amalgam and its components.
3. Do not use in the treatment of children, pregnant and lactating women.

4. Do not use in patients with kidney disease.
5. Direct contact with metallic restorations (crowns), as a result of increased electrogalvanic corrosion going release mercury.
6. The debate as expediency use amalgam for women childbearing age, although the facts of damage to the fetus no mercury.

Question 5. Features of the preparation of cavities for amalgam.

1. The cavities should be at right angles to the prepared and have box-shaped form.
2. The bottom of the cavities should not have sharp corners.
3. The ratio of height to width ratio should ideally not be less than 2:3.
4. The edges of the enamel should be chamfered at an angle of 45 degrees.
5. There should be removed without the support of the enamel and dentin overhanging edges of enamel.

Question 6. The method works with amalgam.

Preparation of the amalgam. The amalgam is mixed in various manners. The ratio of the powder and the mercury is 1:1.

Excessive mercury in amalgams deteriorate mechanical and physical properties of the finished seal (increase turnover increased extension, worsening of fit). With low mercury content increases porosity accelerated corrosion and a perfect seal is broken material that is way when mixing is necessary to observe precisely the mixing ratio specified by the manufacturer. You can guided by the rule that freshly amalgam should not crumble, well spatule be cut.

When using the metering and mixing devices powder and mercury placed in appropriate quantities into the mixing capsule is screwed and mixed.

Alloys are also used in the dosage form of tablets. Tablets are mixed with the necessary amount of mercury is screwed capsule dispenser. Mixing occurs amalgam shaker. Eventually the capsule after repeated use become leaky.

At the moment of amalgam without gamma-2, it is usually supplied in pre-dose capsules. We differentiate between two main capsule system. The activated capsule before mixing is necessary to remove the partition between alloy and mercury. The self-activated capsules pestle during the mixing process breaks the thin partition, shartng both chambers. Capsule systems provide a relatively uniform dosing alloy and mercury.

Condensation amalgam performed after cleaning and drying chamber. Use of rubber dam significantly is increased performance. After contact with the saliva of amalgam properties deteriorate. When using amalgam necessarily sanctioned by an insulating spacer. As the gasket before using

glass ionomer cements. To begin you need to apply an amalgam at a time when the cement is still a little soft. Laying should not go beyond the dentin.

The amalgam is applied into the cavity portions and is condensed. Depending on the product processing time is from 2 to 10 minutes. The first portions of carefully is condensed in interproximal areas of the cavity, the occlusal surface is formed last. Is recommended sealing pressure 1-2 N/mm^2. For spherical, less viscous amalgam condensing pressure lower than for mixed. Under normal circumstances, the choice of method depends on the condensation of amalgam used. Mechanical condenser vides uniform amalgam, including in the areas inaccessible.

Technique of formation and polishing amalgams. The biggest problems arise when setting amalgam to cavity class II Black. When filling cavities 2 class necessarily use matrices and die carriers. Matrixholding designs and shapes of the matrices a lot.

Once the cavity is filled, the time comes to modeling of occlusal fillings, but first you need to remove the matrix from the die. If you do it right, the edge of the seal simply break off. To prevent this from happening you need to immediately cut edge that is in contact with the adjacent tooth. For this tool is taken Hollenback , and, putting a sharp tip to the matrix, make the cut at 45 degrees. Then loosen the screw and the die neat movements removed from the tooth matrix. Now you need to remove the excess amalgam of interdental spaces. To do this, use the same Hollenback (not worth very zealous, amalgam is still very fragile. In order to simulate the chewing surfaces of the instrument can be used Le Cron (it resembles a small knife). Based on the mounds, they are cut off neatly the excess amalgam.

The basic rule modeling. Cut should always be towards the hard tissues of the tooth.

The next phase begins gently with a benisher tool (colloquially "balls", literally - polishers) smooth cut surface, as if lapping amalgam to the enamel margin.

Then check for bite, gently asking the patient's jaw clamp. Final polishing of fillings carried out after 24 hours.

Finishing amalgams. Carefully using boron with the water-cooled areas must be removed to achieve a comfortable and closing movement of the jaws. Then polish the whole seal rubber polishers (green and brown). The final step is finishing the edges of fillings. We pressed as if edge of the filling to the enamel by finishing burs, eliminating any gaps and as if obliterating these edges. The finished seal should shine like a mirror. In the area of the contact point, use the thinnest strips.

Question 7. Safety precautions when working with amalgam.

Amalgam fillings release metal ions in the mouth. The most toxic find mercury release. Mercury is found in various states of aggregation and occurs in the form of various compounds.

In establishing the amalgam patient is subjected to different forms of mercury. Metal, liquid mercury is applied by mixing, it has no significant toxic effect. The vapor of mercury is formed during processing and mechanical failure of amalgam. From the hardened amalgam associated also released a small amount of mercury vapor, then inhaled by the patient. Inhaled mercury from the lungs into the bloodstream (80%), where it is oxidized to form Hg_2 +. However, in this form of mercury is able to overcome the blood/brain barrier, entering the brain and oxidized there. Absorbed Hg in ionic form (Hg_2 +) excreted by the kidneys and partially with faeces on average reduced by half within 60 days. Accumulation of mercury takes place in the kidney and in certain brain regions.

Mercury ions are released during chewing (abrasion), boron removal of amalgam fillings and swallowed with the saliva. From the gastrointestinal tract to digest 7-10% ingests mercury. Mercury ions are not lipid-soluble, but have a greater affinity for sulfhydryl groups. Therefore, inorganic mercury accumulates inside the cells of the liver and kidneys. Inorganic mercury methylates after absorption is not.

Intoxication with mercury occurs in acute and chronic forms.

Acute mercury poisoning is rare. In acute poisoning mercury vapor primarily affects the lungs. Salts of mercury affect the gastrointestinal tract and the kidney, organic mercury compounds act on the central nervous system. The consequence is paresthesia, movement disorders, speech and hearing.

In chronic mercury poisoning unambiguous establishment of communication with their symptoms cause difficult. Chronic mercury poisoning is characterized by objective symptoms:

- Intense trembling fingers, eyelids, lips;
- Individual changes, characterized by irritability, confusion, volatile mood, memory lapses, etc.;
- Speech disorders;
- Nephritis, proteinuria.

In less severe symptoms of poisoning occurs nonspecific, asthenic-vegetative syndrome (micromercurialism). These symptoms, however, may arise in cases not related to mercury poisoning (feeling of weakness, fatigue, weakness, loss of appetite, nervousness, confusion, headache, decreased performance, and others.).

In some cases, amalgam fillings can cause allergic reactions (contact allergy). It manifests a general reaction of the skin (e.g. eczema, dermatitis),

common painful symptoms (e.g., gastroenteritis) or mucosal response (mercury gingivitis, stomatitis). Symptoms occur immediately after application or removal of amalgam fillings and usually disappear within 2-3 weeks. If an allergic reaction to inorganic mercury salts or organic mercury amalgams application is not always accompanied by the rapid development of the disease. Identify an allergic reaction can be by intradermal tests in the presence of allergens (0.1% solution of HgCI, 5% Hg-precipitation ointment metallic mercury from amalgam related). If any allergic reactions to amalgam amalgam fillings are not used.

After contact amalgam with other metals, as well as contact with freshly amalgam previously established amalgam fillings may appear "metallic" taste and discomfort as a result of short-electromechanical processes (oral galvanism). After surface treatment seals are often terminated.

To prevent the occurrence of this kind of ailments should:

1. Stick to the boundary values of the allowable mercury consumption WHO. For workers exposed to mercury (but not for the people, prolonged exposure to mercury), set the maximum permissible limits of mercury absorption, the excess of which can cause chronic poisoning. Thus, the maximum workplace concentration (MKRM value) is 100 mg / m3 and From Biological permissible concentration in working material (BDKRM value) is 200 l / l of urine, or 50 l / l of blood.
2. The office should be provided with sufficient ventilation (natural and artificial).
3. Be sure the availability of personal protective equipment nurses (gown, cap, mask, gloves, goggles).
4. The continuous change of gloves and masks (1 mask changes every 3 hours gloves customized for each patient).
5. It is advisable to use rubber dam when the seals.
6. Use the suction system during polishing amalgam fillings.
7. Disposal of amalgam should be done in accordance with the requirements established by law (the use of amalgam separator, special processing of amalgam waste).

Tests to the topic

1. The amalgam includes:

a. Mercury.
b. Lead.
c. Tin.
d. Silver.
e. Gold.

2. What phase is isolated in the composition of amalgam?

a. Gamma 1.
b. Delta 1.
c. Gamma 2.
d. Delta 2.
e. All of the above is true.

3. By the positive properties of the amalgam should include the following:

a. High mechanical strength.
b. Resistance to abrasion.
c. Long life (30 years).
d. Plasticity.
e. All of the above is true.

4. The negative properties of amalgams include:

a. High thermal conductivity.
b. Lack of chemical adhesion to hard tissues of the tooth.
c. Low coefficient of thermal expansion.
d. A large percentage of shrinkage that worsens marginal integrity seals.
e. All of the above is true.

5. Indications for the use of amalgam fillings are:

a. Filling cavities 1 and Class 2.
b. Filling of cavities class 5 on molars and premolars.
c. Sealing subgingival cavities molar.
d. The cavities in front teeth.
e. All of the above is true.

6. Precautions amalgam includes:

a. The office should be provided with sufficient ventilation (natural and artificial).
b. Make sure the availability of personal protective equipment nurses (gown, cap, mask, gloves, glasses).
c. The continuous change of gloves and masks (1 mask changes every 3 hours gloves customized for each patient).
d. It is advisable to use rubber dam when the seals.
e. Use the aspiration system polishing amalgam fillings.
f. All of the above is true.

7. Contraindications to the use of amalgams are:

a. Chronic mercury intoxication of the body.

b. Allergic reaction to amalgam and its components.
c. Should not be used in the treatment of children, pregnant and lactating women.
d. All of the above is true.

8. Tool for cutting off excess amalgam are:

a. Benicher.
b. Amalgam condenser.
c. Probe.
d. Carver.

9. Tool for smoothing the amalgam surface are:

a. Benicher.
b. Carver.
c. Tweezers.
d. All of the above is true.

10. The ratio of powder and mercury when mixing amalgam should be:

a. 1:1.
b. 1:3.
c. 1:4.
d. 1:5.

LESSON 3.CLINICAL APPLICATION OF COMPOSITE MATERIALS IN THE RESTORATION OF TEETH

The questions to be studied for the learning of the topic:

1. Classification of composite materials.
2. The composition and general properties of the composite materials.
3. Selection of composite materials according to the cavity by Black.
4. Stages of work with composites.

Question 1. Classification of composite materials.

In an effort to improve the physical characteristics of unfilled acrylic resins, Bowen, of the National Bureau of Standards (now called the National Institute of Standards and Technology), developed a polymeric dental restorative material reinforced with inorganic particles. The introduction in 1962 of this filled resin material became the basis for the restorations that are generically termed composites. Basically, composite restorative materials consist of a continuous polymeric or resin matrix in which an inorganic filler is dispersed. This inorganic filler phase significantly enhances the physical properties of the composite (compared with previous tooth- colored materials) by increasing the strength of the restorative material and reducing thermal expansion. Composites possess LCTEs that are one-half to one-third the value typically found for unfilled acrylic resins and nearer to that of tooth structure.

For a composite to haVe good mechanical properties, a strong bond must exist between the organic resin matrix and the inorganic filler. This bond is achieved by coating the filler particles with a silane coupling agent, which not only increases the strength of the composite but also reduces its solubility and water absorption.

Composites are usually classified primarily on the basis of the size, amount, and composition of the inorganic filler. Different types of composite used since its introduction include macrofill composites (also called conventional composites), microfill composites, hybrid composites (including traditional hybrid, microhybrid, and nanohybrid composites), and nanofill composites. Composites also have been classified on the basis of their handling characteristics, for example, as flowable and packable composites.

The composite consists of three structural elements, such as a filler, a binder, and the interphase layer. Its thickness is approximately 10-30 nm (100 to 300 A), but in spite of very small size, interfacial layers largely determines composite. Mechanical properties of the composite depending on their nature determine Xia or preferably one of the components of the composite structure, or they interaction. Thus, tensile strength and flexural

modulus, yield strength, the remaining-accurate failure strain is mainly determined by the nature of the polymer matrix and the properties of the interfacial layer. Compressive strength and surface hardness of the filler largely affects. Abrasion loss typically associated with the hardness of the filler, but it also depends on the quality and dispersion in the interfacial bonding layer. Modern classification of composite filling (restoration) materials is built taking into account a number of factors:

A. The particle size of the filler.

1. Macrfilled (particle size 8-45 microns).
2. Microfilled (particle size 0,04-0,4 mm).
3. Composites with small particles (mini) (particle size 1-5 microns).
4. Hybrid (a mixture of particles of different sizes ranging from 0,04 to 5 microns, a mean particle size 1-2 microns).
5. The micro-hybrid (hybrid composites with a particle size of 0,04 to 1 micron, the average time-micron particle size 0,5-0,6).
6. Nanocomposites by using nanotechnology:
   - ✓ true nanocomposites;
   - ✓ microhybrid composites is modified nanofiller (nanohybrid).

B. Method of curing

1. Chemical cure - of type I.
2. The heat curing - type I A.
3. The light-curing - type II.
4. Dual-curing:
   - ✓ chemical + light
   - ✓ light + thermal

C. Consistency

1. "Traditional" Composites usual consistency.
2. Liquid (fluid) composites.
3. The condensable composites.

D. Purpose:

1. For the filling posterior teeth
2. For filling of anterior teeth.
3. Universal Composites.

Question 2. Structure and general properties of composite materials.

Despite the fact that in the composite material to the binder (organic) substance falls considerably smaller volume than the inorganic mineral filler (about 20-25 volume or 35% by weight), composites refer to polymeric material. The binder (the polymer, the polymer matrix) provides fluidity and plasticity of the material in its original state upon application of the seal, and after curing been ensured vides form stability, solidity, integrity. The nature of the composite curing process, radical polymerisation of monomers, the

binder depend largely on the properties of the seal and quality tooth restoration, working time and curing time, color stability and edge integrity, strength and durability. As the main component of the polymer binder used in the composites monomer bis-GMA or a derivative thereof. Quality and quantity of diluent monomer, in the presence-sponding part of the polymer matrix to affect the strength of the cured material, material shrinkage, curing rate, the amount of residual monomers and other properties of the composite.

The fillers in composites. The main requirements for a filler for composite materials are: high chemical resistance; low water solubility; radiopacity; compliance is light-refractive index of the filler and the polymer matrix. The filler used in the composite materials of various modifications silica (amorphous silica as a microfill, quartz), barium, strontium and zirconium glass, alumina, hydroxyapatite and some other inorganic compounds. The fundamental importance to the quality of the composite has a particle size of the filler, and the nature-stick particle size distribution.

The most common currently microhybrid and hybrid composites. In recent created for the purpose of strengthening micro-filled composites, while maintaining high-quality of the aesthetic. Through clever modification fillers created new types of composites, which differ in the original pasty state rheological properties - fluid and dense (condensable or packable).

Strength, modulus of elasticity and toughness of the composites increased with increasing Co-content of the filler, and the ability to polishing and aesthetic properties with reduced. Therefore, it is difficult to create a truly universal composite for all Sun-tooth formation. Improving composites follows the path of the hardening materials and porous fibrous fillers, the introduction of fillers anticaries properties, improving filler processing technology to reduce internal stresses in the polymer matrix.

The handling of the filler and the formation of the interfacial layer.

The interphase layer in composites created by reacting the solid and the liquid binder in the filler particle surface. To accomplish this, the interaction of the inorganic filler particles are treated with special chemicals, so-called binders.

According to the international standard (ISO), the main features of the composites are:

1. The presence of the polymer matrix, usually based on copolymers of acrylic and epoxy resins.

2. The presence of more than 50% by weight of an inorganic filler.

3. Treatment of the filler particles special surfactants, good-giving he enters into a chemical bond with the polymer matrix.

Peculiarities of chemical composition and spatial organization of composites cause a number of positive and negative qualities and affect the

method of their clinical application. It is therefore advisable to consider in more detail the characteristics of each of the 3 parts (or phases).

A polymer matrix composites (organic matrix). This connection is the basis of most modern composites and called Bis-GMA (bisphenol glycidyl methacrylate). It is a monomer with a high molecular weight. This hybrid molecule which are bonded to the epoxy resin reactive methacrylic group. Other substances used in the manufacture of composite comrade called uretandemetilmetakrilat (UDMA). It performs the same role as the Bis-GMA, but has a lower polymerization shrinkage, gives the material a higher density and so forth-ness. In the manufacture of composites are also used other monomers dekandioldi methacrylate (D3MA) or triethylene glikoldimetakrilat (TEGDMA), making possible to reduce the viscosity of the polymerization and the material. One area of improvement is a modification of the composite material of the polymer matrix. Polymer matrix of further comprises:

1. The polymerization inhibitor - for longer working with the material, and lengthening the shelf life.
2. Catalyst - to initiate polymerization.
3. Additional catalyst (co-catalyst) - to improve the process of-polymerized (only chemical curing composites).
4. The activator (photoinitiator polymerization) to initiate the polymerization (only photocurable composites).
5. The ultraviolet absorber - to improve color stability; decreasing discolouration of the material when struck by sunlight.

*B. Filler (dispersed phase).*The inorganic (mineral) filler is an integral part of modern component-posits. Due to the large amount of filler is achieved improvement in the properties of composite plastic materials, namely:

- decreases polymerization shrinkage (to 0,5-0,7%);
- preventing deformation organic polymer matrix;
- is reduced coefficient of thermal expansion;
- is reduced water sorption;
- is increased hardness of the material and its resistance to abrasion and stress;
- improve aesthetic properties of the material as its filler has a refractive index and translucence, close to the relevant indicators of the tooth enamel.

The main properties of the filler affect the quality of the composite are as follows:

1. The size of the filler particles. This indicator is the most important parameters determining-conductive properties of the material. In various

composites, it ranges from 45 microns to 0.04 microns (1 micron = 1 micrometer microns).

2. The material of the filler is made. It is used a large number of diverse different fillers: fused and crystalline quartz, aluminosilicate, and borosilicate barium glass, various modifications of silicon dioxide, diamond dust, artificially synthesized substances, etc.

3. The shape of the particles. The filler may be powder, spherical shaped "whiskers", sticks or chips. Most composites used milled particles radiopaque barium glass, but some manufacturers prefer synthetic fillers with spherical particle.

The variation of particle size, shape and material which is made from a filler-key it possible to modify the properties in the desired direction.

B. Surfactants (intermolecular force or phase), also called sizing (from French - appreter - impregnated impart properties).

Ensuring a stable, reliable communications between the filler and the polymer matrix is a necessary condition for obtaining a durable and resistant composite materials. If this relationship is absent or expressed enough, along the border "fill-Tel / polymer matrix" can easily penetrate moisture and coloring agents, and the filler is easily knocked out from the surface of the material.

To avoid this phenomenon, the surface treated filler con-specific binding agent (silane). From a chemical standpoint are silicone compounds. These binders are bipolar connecting chemical bond on one side with a filler, and on the other with the organic matrix. Due to the presence of silanes composites acquire improved properties:

- ✓ filler particles are water-repellent (hydrophobic)
- ✓ is reduced water absorption of the material, it improves color stability
- ✓ sharply increased strength and durability.

Macrofill (or Conventional) Composites. Macrofill composites were the first type of composites introduced in the early 1960s. Although these types of composite restorations are sometimes found in some older patients, they are no longer used in clinical practice. Macrofill composites generally contained approximately 75% to 80% inorganic filler by weight. The average particle size of conventional composites was approximately 8μm. Because of the relatively large size and extreme hardness of the filler particles, macrofill composites typically exhibit a rough surface texture.The resin matrix wears at a faster rate than do the filler particles, further roughening the surface. This type of surface texture causes the restoration to be more susceptible to discoloration from extrinsic staining. Macrofill composites have a higher amount of initial wear at occlusal contact areas than do the microfill or hybrid types.

Most conventional composites currently have been supplanted by hybrid composites (see later) but may still be encountered in older patients.

Microfill composites were introduced in the late 1970s. These materials were designed to replace the rough surface characteristic of conventional composites with a smooth, lustrous surface similar to tooth enamel. Instead of containing the large filler particles typical of the conventional composites, microfill composites contain colloidal silica particles whose average diameter is 0.01 to 0.04 8μm. Because of the greater surface area per unit volume of these microfine particles, however, microfill composites cannot be as heavily filled because of the significant surface area per unit of volume. Typically, microfill composites have an inorganic filler content of approximately 35% to 60% by weight. Because these materials contain considerably less filler than do conventional or hybrid composites, some of their physical and mechanical characteristics are inferior. Nonetheless, microfill composites are clinically highly wear resistant. Also, their low modulus of elasticity may allow microfill composite restorations to flex during tooth flexure, better protecting the bonding interface. This feature may not have any effect on material selection for Class V restorations in general, but it might make microfill composites an appropriate choice for restoring Class V cervical lesions or defects in which cervical flexure can be significant.

Hybrid composites were developed in an effort to combine the favorable physical and mechanical properties characteristic of macroiill composites with the smooth surface typical of the microfill composites. These materials generally have an inorganic filler content of approximately 75% to 85% by weight. Classically, the filler has been a mixture of microfiller and small filler particles that results in a considerably smaller average particle size (0.4-1 pm) than that of conventional composites. Because of the relatively high content of inorganic fillers, the physical and mechanical characteristics are generally superior to those of conventional composites. Classic versions of hybrid materials exhibit a smooth "patina-like" surface texture in the finished restoration.

Current versions of hybrid composites also contain ultrasmall nanofillers, resulting in superior characteristics. These newer versions of hybrid composites are called nanohybrid composites.

Nanofill composites contain filler particles that are extremely small (0.005-0.01 pm). Because these small primary particles can be easily agglomerated, a full range of filler sizes is possible, and optimal particle packing is facilitated. Alternatively, many classic hybrid composites have simply incorporated nanofillers into the existing filler composition, thereby optimizing the material further. Consequently, high filler levels can be generated in the restorative material, which results in good physical properties and improved esthetics. The small primary particle size also makes

nanofills highly polishable. Because of these qualities, nanofill and nanohybrid composites are the most popular composite restorative materials in use. These composites have almost universal clinical applicability and are the primary materials referred to as composites throughout this book.

Packable composites are designed to be inherently more viscous to afford a "feel" on insertion, similar to that of amalgam. Because of increased viscosity and resistance to packing, some lateral displacement of the matrix band is possible. Their development is an attempt to accomplish two goals:

1) easier restoration of a proximal contact;
2) similarity to the handling properties of amalgam.

Packable composites do not completely accomplish either of these goals. Because of the increased viscosity, it is typically more difficult to attain optimal marginal adaptation, prompting some clinicians to first apply a small amount of flowable composite along proximal marginal areas to enhance adaptation.

Flowable composites generally have lower filler content and consequently inferior physical properties such as lower wear resistance and lower strength compared with the more heavily filled composites. They also exhibit much higher polymerization shrinkage. Although manufacturers promote widespread use of these products, they seem to be more appropriate for use in some small Class I restorations, as pit-and-fissure sealants, as marginal repair materials, or, more infrequently, as the first increment placed as a stress-breaking liner under posterior composites. Additionally, flowable composites are being used as first small increments in the proximal box of a Class II restoration in an effort to improve marginal adaptation. This approach is somewhat controversial but may be indicated in conjunction with the use of thicker, packable composites, where optimal marginal adaptation is more difficult to achieve.

Some manufacturers also are currently marketing flowable composites as bulk-fill materials, to be used to restore most, if not all, of a tooth preparation in posterior teeth. The manufacturers claim reduced polymerization shrinkage stress, which may occur because of the low elastic modulus of the flowable materials. However, the physical properties of flowable composites are generally poor, and the long-term performance of such restorations is not yet proven. Whether or not flowable composites are used for bulk-filling, they should never be placed in areas of high proximal or occlusal stress because of their comparatively poor wear resistance. More heavily filled composites are far superior for restorations involving occlusal or proximal contact areas.

Thus, in view of the above, it is legitimate to the following definition of composite: composite material - a complex compound, which is based on an organic polymer resin, in which to improve the properties introduced

inorganic filler these components chemically bonded to each other via a bipolar molecular surfactants silanes. The resulting material gets improved properties that can not be obtained when using each of these components separately.

Question 3. Selection of composite materials according to the cavity by Black.

Macrofilled composites are:

1. Filling cavities classes I and II.
2. Filling of cavities class V in chewing teeth.
3. Filling cavities in front teeth, if not required aesthetic effect (for example, the localization of cavity on the lingual surface).
4. Restoration of severely damaged anterior crowns followed coating vestibular surface more aesthetic, for example, microfilled composite.
5. Modeling stump tooth for a crown.

Positive properties of composites makrofilled:

- ✓ high strength;
- ✓ acceptable optical properties;
- ✓ radiopacity.

The negative properties of this group of composites:

- ✓ difficulty of polishing, the lack of "dry shine";
- ✓ high surface roughness;
- ✓ pronounced accumulation of plaque;
- ✓ poor color fastness.

Microfilled composites are:

1. The filling of cavities class III;
2. The filling of cavities class V;
3. The filling defects in non-carious lesions (erosion of enamel hypoplasia, wedge-shaped defects, etc.);
4. The production of aesthetic adhesive facings (veneers) without overlapping the edges of the cutting teeth;
5. The aesthetic filling cavities Class IV and the restoration of a tooth crown in traumatic injury - in combination with hybrid or makrofilled someone positive and pins (pins).

Positive properties:

- ✓ an excellent polishing
- ✓ the resistance glossy surface
- ✓ a high color fastness
- ✓ a good aesthetic qualities
- ✓ a low abrasion.

Negative properties:

- ✓ a low mechanical strength
- ✓ a high polymerization shrinkage
- ✓ a high coefficient of thermal expansion.

Minifilled composites. The properties they occupy an intermediate position between the micro and makrofilled-governmental composites. These materials have a satisfactory aesthetic, physical and mechanical properties. Composites are intended for the restoration of the group chewed-enforcement teeth (small cavities) and anterior teeth. However, due to low strength and poor polishability widespread they are not received.

Hybrid composites. Hybrid composites are considered universal filling materials, but when filling cavities II and IV classes of their application are not always effective. When high aesthetic demands, is combined with the need to ensure high seal strength of hybrid composites used in combination with microfilled composites and pins.

The positive properties of the hybrid composites are:

- ✓ an acceptable aesthetic properties;
- ✓ a sufficient strength;
- ✓ a surface quality seals better than makrofilled composites;
- ✓ a radiopacity.

The negative properties are:

- ✓ not perfect surface quality (worse than the micro-filled composites);
- ✓ an insufficient polishing, the low resistance of a dry finish.

Micro-hybrid composites are:

1. The filling the cavities of the five classes of Black in anterior and posterior teeth
2. The production of vestibular aesthetic adhesive facings (veneers);
3. The repair (restoration) chipped porcelain crowns.

The properties of micro-hybrid composites, providing them quality universal restoration materials:

- a good aesthetic quality;
- a good physical and mechanical properties;
- a good polishing;
- a good surface quality;
- a high color stability.

Question 4. Stage of working with composite materials.

1. The cleansing the tooth surface.
2. The planning of building restoration and choice of color filling material: anatomical diagnostics; color diagnosis (hue, chroma, translucent

bridge, opalescence, fluorescence, metamerism (metamerism, chameleon effect).
3. Preparation of cavities.
4. The isolation of tooth from saliva.
5. Drug treatment and drying the cavity.
6. Overlay pads.
7. The use of the adhesive system.
8. Adding to the cavity and curing composite filling material.
9. Finishing of the restoration.
10. Recommendations to the patient.
11. Control examination of the patient, assessment of the quality of the restoration.

Tests to the topic

1. By appointment composite materials are classified:

a. For filling posterior teeth.
b. The condensable composites.
c. For fillings in front teeth.
d. Universal composites.
e. Liquid (fluid) composites.

2. List the main characteristics of composites:

a. The presence of the polymer matrix, usually based on copolymers of acrylic and epoxy resins.
b. Having more than 50% by weight of an inorganic filler.
c. Processing special filler particles surfactants, through which it enters into a chemical bond with the polymer matrix.
d. All of the above.

3. Indications for use micro-hybrid composites are:

a. Filling of cavities of all five classes according to Black in the anterior and posterior teeth.
b. Modeling tooth stump to be crowned («Coradent», Vivadent; «Rebilda», VOSO).
c. Making the vestibular aesthetic adhesive facings (veneers).

4. The positive properties of the hybrid composites include:

a. Acceptable aesthetic properties.
b. Sufficient strength.
c. Surface quality seals better than makrofilled composites.
d. Radiopacity.
e. All of the above.

5. The indications for use minifilled composites are:

a. Filling defects in non-carious lesions of teeth (enamel erosion, hypoplasia, wedge-shaped defects, etc.).
b. Filling of cavities class V in chewing teeth.
c. Restoration of posterior teeth (small cavities) and anterior teeth.
d. Repair (restoration) chipped porcelain crowns.

6. List the indications for using Ceram X:

a. Filling of cavities I-V class.
b. Restorations for anterior and posterior teeth.
c. No restrictions.

7. Select the type of filler in Filtek Z250 material:

a. Nanoparticles.
b. Microparticles.
c. Microdispersed hybrid composite.

8. Average particle size of the filler material Ketac-Fil is:

a. 6.25 μm.
b. 12.5 μm.
c. 2,7 μm.

9. The shrinkage of bis-GMA is:

a. 3%.
b. 12%.
c. At 7%.

10. Select the type of filler in Charisma material:

a. Nanoparticles.
b. Microparticles.
c. Microdispersed hybrid composite.

LESSON 4. ADHESIVE PREPARATION METHODS USED IN TEETH RESTORATION

The questions to be studied for the learning of the topic:

1. The adhesive system, definition, classification.
2. The requirements for the adhesive system.
3. Indications and contraindications to the use of adhesive systems.
4. Mechanisms binding adhesive systems to the tooth. The concept of "hybrid layer".
5. Characteristics and methods of work with the adhesive systems 1, 2, 3 generations.
6. Adhesive system 4, 5, 6, 7 generations. The composition, properties and methods of work.

Question 1. The adhesive system, definition, classification.

The adhesive system is a set of liquids comprising etching component and primer bond and promotes micromechanical and some cases chemical fixation of dental material (composite, amalgam, ceramics) directly to the hard tissues of the tooth. Adhesive systems are:

1) over the generations:

a) 1st generation; b) 2nd generation; c) third generation; d) 4th generation; e) 5th generation; e) 6th generation; g) 7th generation;

2) the number of filler:

a) unfilled; b) filling; c) nanocomposite;

3) the type of the solvent:

a) containing acetone; b) containing alcohol; c) water-based; d) combined;

4) for other purposes:

a) enamel-dentine adhesive systems (for adhesion all light materials);

b) universal adhesive system (for adhesion of light, chemical and dual-curing);

c) multifunctional adhesive system (for adhesion composite filling materials, ceramics, amalgam alloys);

5) a process for the polymerization:

a) light-curing; b) self-curing; c) dual-cure;

6) The mechanism of action:

a) the self-etching system;

b) the systems with total-etch dental tissues.

Recent advances in the development of adhesive dentistry is self-etching systems. The popularity of self-etch adhesive systems in the world is constantly growing. Today we can see major classes of self-etch systems:

1) the self-etching praymery (include 2-3 bottles require a separate application components), including two subspecies:

a) the one-bottle system self-etching agent (indelible conditioner to enamel and dentin primer + one-bottle system and bond);

b) the self-etching primer + bond;

2) one-step self-etching adhesives to be mixed (include 2 bottle, the components must be mixed prior to application, is required one application of the material);

3) one-step self-etching adhesives immiscible (1 bottle, is not required to mix the components, it requires one application of the material).

Question 2. Requirements for the adhesive system.

1) To be universal and compatible with the majority of dental materials;
2) To provide an immediate, sustained load, long-lasting effect of binding to the tooth;
3) Offset voltage, resulting from the polymerization shrinkage of the composite material;
4) Have the force of adhesion to dentin, similar or equal adhesion to enamel;
5) Provide a sufficient adhesion to the wet surface of the dentin;
6) To be biocompatible, does not cause irritation and loss of pulp in the next and long-term periods;
7) They should be insoluble when in contact with dentin and the oral liquids;
8) To provide convenience and ease of use;
9) Have a longer shelf life;
10) Does not have a sensitizing effect on the patient and the physician.

Question 3. Indications and contraindications for adhesive systems.

Clinical indications for the use of adhesive systems:

1) For direct the restoration of cavities I-VI classes on Blake;
2) For treatment of dentin sensitivity of the tooth root;
3) For protection of the pulp after tooth preparation for orthopedic design;
4) For adhesive technique with an amalgam;
5) For preparation of the tooth before committing indirect restorations (ceramic, composite, composite crowns, bridges, inlays, onlays, and all types of intracanal pins);
6) For fixing the teeth of orthodontic devices (braces);
7) For direct reduction in the oral cavity of the composite old fillings, amalgam, ceramic, cermet, crowns.

The clinical contraindications for the use of adhesive systems:

1) Poor oral hygiene of the patient;

2) The inability to isolate the field from saliva;
3) Allergy to any component of the adhesive system by a dentist or a patient.

Question 4. The mechanism of binding adhesive systems to the tooth. The concept of "hybrid layer".

Formation of a hybrid layer at the level of enamel. The first step in the preparation of the enamel is the treatment of the surface layer of enamel acid in those certain time. As a result dissolution inorganic substances is formed on the enamel surface microtopography of long grooves, the grooves 25 microns deep. The area of con-tact with the surface of the enamel thereby greatly increased.

The optimum concentration for the etching agent in the etching technique total-etch technique today is considered to be 20-40% acid. 37% phosphoric acid uses most commonly. Preferably use pickling as a gel. After washing off the etching agent is dried enamel. Enamel after etching optimally should be slightly brushed without excess moisture.

The hydrophobic organic resin included in the bond, it is easy to fill the space enamel microrelief. After polymerization, the bond in the surface layer of enamel is formed firmly connected with it, thanks mikroretentsiya of material hybrid layer.

When using the self-etch enamel demineralization systems it passes through a different mechanism, since there is no step of washing and drying enamel etching.

Formation of a hybrid layer at the level of dentin.

Getting a strong bond to dentin adhesive system is more complex, due to the peculiarities of the morphology, physiology, and chemical composition of the dentin.

To achieve adhesion to dentin originally anticipated through the smear layer having a bond to dentin, but a large number of studies have shown that the strength of adhesion in these cases did not exceed 3 MPa and often is occurred depressurization. Later, modified proposed smear layer through its partial dissolution, but the power of communication has increased considerably - 8-10 MPa. First Nakabayashi and colleagues described the changes in the morphology of dentine after acid etching and dentin after impregnating resin, coined the term "hybrid layer". Then Fusayama proposed one-stage etching by acid of enamel and dentine, later called total etching. Many dentists with fears at the idea of acid etching dentine, because they believed that this will cause irritation and loss of pulp. Scientifically it has been proven that complete elimination the smear layer by etching knowledge-significantly increases the adhesion of the materials to dentine, with an average of more than 20 MPa, without causing irreversible changes in pulp

nearest and remote terms. For a long time it was recommended to dry dentin after etching, as well as enamel. However, this approach leads to poor penetration of the resin into the dentine structure, decrease traction and frequent occurrence of postoperative sensitivity. In the early 90's John Kanca offered wet bonding technique, which later gained recognition and wide spread. After polymerization, the hybrid layer is formed securely connected to the underlying dentin.

Question 5. Characteristics and methods of working with the adhesive system 1, 2, 3 generations.

The first generation of adhesive systems appeared in the mid-70s. At the level of enamel adhesion is ensured by fixing micromechanical bond. At the dentin level communication mechanism was based on ionic interaction with the blurred layer. These materials contain bifunctional molecules that one end contacted with calcium ions lubricated layer, and the other - with a monomer in the composition of the composite material. The member of this generation is the Cosmic Bond. The bond strength to dentin was 1-3 MPa. It was not enough, as evidenced by the negative clinical results.

The second-generation adhesive systems appeared in the late 70s and was characterized non-significant increase in bond strength to dentin to 4-8 MPa. The members of this generation are Bondlite, Dual-Cure Srotchbond, Creation Bonding Agent. Most of them were a mixture of phosphoric acid esters with resins (Bis-GMA or HEMA) without on-filler. Mechanism due to dentin is still based on the ionic interaction with the blurred layer. Clinical results have shown that the majority of restorations became insolvent in the first two years. Studies in vitro have shown that the link-layer Lubricate dentin insufficient and unstable, causing depressurization between the seal and the forelock.

The third generation of adhesive systems appeared in the mid-80s. Their main difference from previous generations is that the treatment was applied to the dentin modification of the smear layer. As a rule, it was system which includes two-component primer (Primer A, Primer B) and Bond (Bond). Enamel separately etched with 37% phosphoric acid, and the processing carried dentin primer comprising organic acid (EDTA, maleic acid) monomer (4-META or HEMA) and solvent (alcohol or acetone) that enhanced Dentin permeability. Modification of the smear layer of organic acid, a hydrophilic monomer allowed to infiltrate it, providing a link with the surface layer of dentin. Although the smear layer modification, adhesion to dentine remains quite low (5 MPa 10-1). The final phase of training involves applying an adhesive bond containing hydrophobic monomers (Bis-GMA, UDMA, TEGDMA). The members of this generation are ART Bond, All-bond, Denthesive, Gluma, Scothbond 2, Superbond, Tenure, Metabond,

Amalgambond, Syntac Classic, XR Bond et al. Alienate-WIDE clinical results of the use of these systems were better, but working with them is time consuming due to the use of sophisticated equipment.

Today adhesive systems 1-3-th generation are not used in the dental practice.

Question 6. Adhesive system 4, 5, 6, 7 generations. Composition, properties, methods of work.

The fourth-generation adhesive systems are developed over a decade ago, still has a considerable weight in the dental market due to its reliability and flexibility, time-tested. The members of this generation are the All-Bond 2, AmalgamBond Plus, OptiBond FL, Perma Quick, ScotchBond Multipurpose plus, Solid Bond, Definite Multi-bond.

A prerequisite for good adhesion to dentin is the preservation of its surface with a slightly damp, so-called bonding wet bonding, which prevents the collapse of collagen fibers. As a rule, the system of the 4th generation represented two bottles: Primer and Bond. Technique their use involves at least three steps: etching, priming (priming), the application of the bond. After remove the smear layer on overdried dentin primer is applied and rubbed it into the dentin surface with light massaging movements on average 20-30 seconds. After processing the entire surface of the dentine should shine, requiring 1 to 5 applications. This is followed by polymerization according to the manufacturer's instructions. Most systems 4th generation are multifunctional. They are designed for fixing to the tooth ceramics, metal alloys, composites and amalgams. Advantages: high adhesion strength to enamel and dentin especially (on average more than 20 MPa), good long-term clinical results, multi-functionality.

Disadvantages: the complexity of the work, high sensitivity to infringement of stages of the work, the risk of transmission of infection, high enough price.

The fifth generation adhesive systems appeared in the mid-90s. This group of materials is represented by so-called one-bottle adhesive systems (one-bottle systems), which primer and bond are in the same solution. Classical use technology comprises two stages: the total-etch enamel, dentin, cement (CE 15-30 seconds), and application mix primer bond (20-30 seconds), followed by polymerization.

Representatives of this group are Exite, Gluma Comfort Bond (Desensitizer), One Step (Plus), OptiBond Solo (Plus), PQ1, Prime & Bond NT, Single Bond, Adper Single Bond 2, Tenur Quick, Easy Bond, Fuji Bond LC, One (oat Bond, Solobond M, Admira Bond et al.

The first version of the one-bottle systems (Gluma One Bond, Prime & Bond demanded several applications (2-3) to reach the desired result, that do

not give the winning time. Later versions of the one-bottle systems have been improved and now demanded only single applications of the material (Prime & Bond NT, Exite).

Advantages: high bond strength to enamel and dentine; Suggested good clinical results; convenience in work, less time and the number of work steps, compatible with all light-curing materials.

Disadvantages: adhesion to enamel exceeds the bond strength to dentin, sometimes significantly, which leads to the separation of the restoration of the dentin; the frequent occurrence of postoperative sensitivity; the inability of most materials use this group the chemically curing materials.

The sixth and seventh-generation, self-etch adhesive systems, the first version of which appeared in the early 90s.

The sixth generation of self-etching primers and includes a self-etching adhesives.

Self-etching primers today presented a large group of materials which can be divided into two types:

1) of the "primer with pickling + Bond»: Clearfil Liner Bond, Clearfil Liner Bond 2 V, Clear-fil SE Bond, AdheSE, FL-Bond, Contax, Nano-Bond;

2) System "self-etching primer with Agent + Bond»: NRC with Prime & Bond NT, OptiBond Solo Plus Self-Etch Adhesive System, One Step (Plus) with Tyrian SPE.

There is not principal difference in efficacy between the two types of primers self-etching, but there are differences in the technique of working with them.

Advantages: a quick and easy method of operation, the almost complete absence postoperative sensitivity, higher rates of adhesion to dentin in comparison with the one-bottle systems multifunctional similar systems of the 4th generation.

Disadvantages:

1) The effectiveness of the acid treatment surface intact enamel and dentin sclerotic lower than when using total etching;

2) high hydrophilicity and acidity components affect the stability of the hybrid layer. According to several studies in vitro (vivo), these systems are characterized by a lower durability of the hybrid layer compared with systems 4 and 5th generation;

3) a shorter shelf life, typically in a refrigerator.

Self-etching adhesives appeared in the late 90s and represent a two-component system requiring mixing prior using. Representatives of this group are FuturaBond (NF), Etch & Prime 3.0, Adper Promt L-Pop, Xeno III, One-Up Bond F, Touch & Bond, Tenure Uni-Bond. The cardinal difference from the self-etch primer to conduct a one-time etching, priming and bonding, which gives considerable advantage in time.

Advantages: no stage etching and rinsing, shorter-term preparation of the adhesive is very simple technique works almost complete absence of postoperative sensitivity.

Disadvantages:

1) The absence of long-term clinical results of their use, great extensibility in terms of adhesion to the enamel and dentin;

2) efficiency acidizing surface intact enamel and dentin sclerotic lower than when using total etching;

3) High hydrophilicity, and the acid component affects the stability of the hybrid layer;

4) For large restorations require multiple coatings optimal results;

5) Chemical instability of the composition with prolonged storage.

Self-etching adhesives 7th generation appeared in the last 3 years, is the latest development in the adhesive stomatology. For most of the parameters are identical self-etching adhesives 6th generation. The difference lies only in the presence of-phase mixing of the components, as these systems are presented with a solution containing etchant, primer and bonding agent. Representatives of this group are i-Bond, Xeno IV, Brush & Bond. Composition i-Bond: UDMA, 4-META, water, acetone, camphorquinone, glutaraldehyde, stabilizers without filler. Composition Hepo IV: monomer PEM-F, UDMA, PENTA, water, alcohol, stabilizers, nanofiller. Both systems are available in bottles and SingleDose. Scheme of them involves a preliminary shake solution, then applying it to dentin and enamel of several layers, starting with enamel exposure during 30 seconds, and polymerization inflating air 10-20 seconds. For large restorations manufacturers recommend repeat 2-3 times. Brush & Bond, which is a hydroacetone mixture with 4-MFTA, differs from these systems. It does not require shaking prior due to new patented system of tri-functional monomers can be used with all materials and chemical dual-cure initiators has a new system, which is polymerized material under the influence all currently known dental light sources (halogen, LED, plasma lamps and lasers). Driving with Brush & Bond involves application on the prepared enamel, dentine and cement for 20 seconds, inflating air for 5-10 seconds, 3-10 seconds, and polymerization. The minimum time of the adhesive preparation using those systems is 35 seconds. The risk of postoperative sensitivity when dealing with the systems of the 7th generation is very low due to lack of opportunities and drying overpickling dentin.

In general, these systems are hardly been studied both in vitro, and in vivo, and results of evaluations of various expert organizations contradictory enough.

Advantages: very simple and fast method of work, the almost complete absence postoperative sensitivity, low risk of transmission.

Disadvantages: lack of long-term clinical results of their use, the effects of etching dental hard tissues and the stability of the hybrid layer in question is not large, the shelf life of the material.

Tests to the topic

1. Requirements for the adhesive system are

a. Be universal and compatible with the majority of dental materials.
b. To provide an immediate, sustained load effect.
c. Increase the shrinkage of composites.
d. Have the force of adhesion to dentin, similar or equal adhesion to enamel.
e. To ensure a durable effect of binding to the tooth.

2. The adhesive systems provide:

a. Adhesion to the tooth all light filling materials (composites, compomers, ormokers).
b. Adhesion to the tooth material and chemical dual-cure.
c. Adhesion to tooth structure and amalgam dental materials.
d. Adhesion to the tooth ceramics, precious and non-precious alloys.
e. All of the above is true.

3. Clinical indications for the use of adhesive systems are

a. Direct the restoration of cavities class IV Black.
b. Treatment of the tooth root dentin sensitivity.
c. Protection of the pulp after tooth preparation for orthopedic design.
d. Fixation on prosthetic teeth.
e. Fixation of orthodontic appliances.

4. Enamel etching is most often used:

a. 37% orthophosphoric acid.
b. 15% hydrochloric acid.
c. 5% orthophosphoric acid.
d. 25% phosphoric acid.
e. 10% sulfuric acid.

5. Features of fifth generation adhesive systems are:

a. The presence of a bonding system in the same vial as the primer.
b. The strength of adhesion is 27 - 31 MPa.
c. Filled with microparticles for the release of fluorine, during polymerization the formation of a thicker film.

d. Monomer of the adhesive system is an acid that over time contributes to the neutralization reaction; photoinitiator is alkali of a one-component adhesive system is stored for a shorter period.
e. All of the above.

6. Thickness of the film formed on the surface of hard tooth tissues when using nano-filled adhesive systems:

a. 5-10 μm.
b. 10 to 25 μm.
c. 30 -40 μm.
d. 50-70 μm.
e. 100 μm.

7. Unfilled adhesives are used for:

a. Fixing tabs.
b. Fixing the linings.
c. Fixation of crowns.
d. All of the above.

8. The 7th generation adhesive systems include:

a. Air conditioning.
b. Primer.
c. Desensitizer.
d. Bond.
e. All of the above.

9. Disadvantages of the 4th generation adhesion systems are:

a. Complexity of technology.
b. Large time costs.
c. The probability of development of collapse of collagen fibers of demineralized dentin.
d. Risk of postoperative sensitivity.
e. All of the above.

10. Indicate a complicated chemical complex designed to impregnate dentin structures to form a hybrid layer:

a. Bond.
b. Primer.
c. Etching.
d. Air conditioning.
e. Desensitizer.

LESSON 5. DEVELOPMENT MECHANISM, CLASSIFICATION OF PULPITIS.

The questions to be studied for the learning of the topic:

1. Definition of pulpitis.
2. Etiological factors of the pulpitis development.
3. Pathogenetic aspects of the pulpitis development.
4. Classifications of pulpitis.

Question 1. Definition of pulpitis.

The dental pulp is soft tissue of mesenchymal origin located in the center of a tooth (fig. 1).

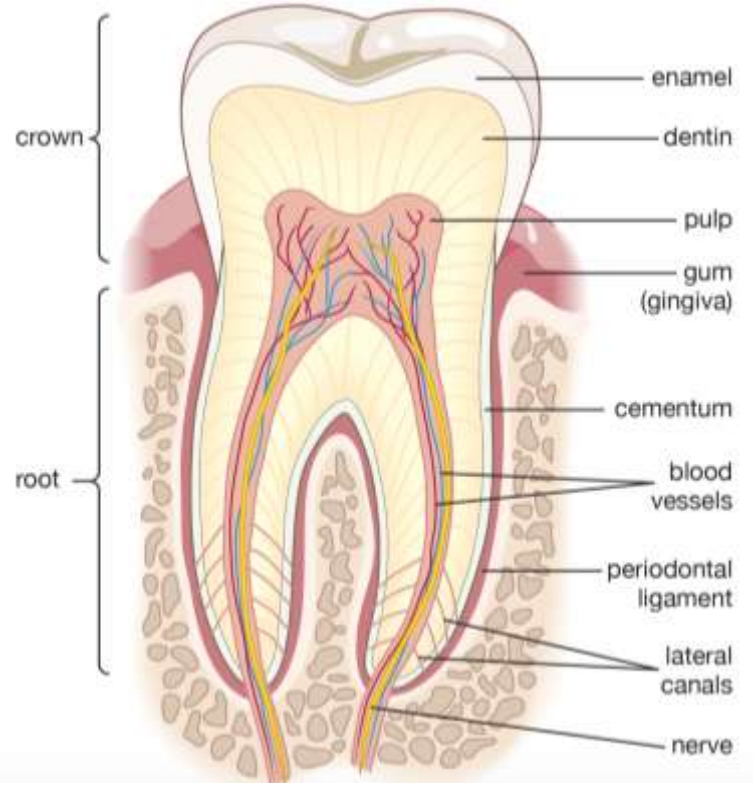


Figure 1. Tooth Anatomy

It is the principle source of pain in oral cavity and also a major site of attention in endodontics and restorative procedures. It consists of specialized cells, odontoblasts, arranged peripherally in direct contact with dentin matrix. This close relationship between odontoblasts and dentin is known as «pulp-dentin complex». The pulp is connective tissue system composed of cells, ground substance, fibers, interstitial fluid, odontoblasts, fibroblasts and other cellular components. Pulp is actually a microcirculatory system consisting of arterioles and venules as the largest vascular component. Due to lack of true collateral circulation, pulp is dependent upon few arterioles entering through

the foramen. Due to presence of the specialized cells, i. e. odontoblasts as well as other cells which can differentiate into hard tissue secreting cells; the pulp retains its ability to form dentin throughout the life. This enables the vital pulp to partially compensate for loss of enamel or dentin occurring with age. The injury to pulp may cause discomfort and the disease. Consequently, the health of pulp is important for successful completion of the restorative procedures. The knowledge of pulp is essential not only for providing dental treatment, but also to know the rationale behind the treatment provided.

Composition of the pulp:

1. Cells:
   – odontoblasts;
   – fibroblasts;
   – undifferentiated mesenchymal cells;
   – defense cells (macrophages, plasma cells, mast cells).
2. Matrix:
   – collagen fibers (type I, type II);
   – ground substance (glycosaminoglycans, glycoproteins, water).
3. Blood vessels (arterioles, venules, capillaries).
4. Lymphatics (draining to submandibular, submental and deep cervical nodes).
5. Nerves:
   – subodontoblastic plexus of Raschkow;
   – sensory afferent from V nerve and superior cervical ganglion.

When pulp examined histologically, it can be distinguished into four distinct zones from periphery to center of the pulp.

Zones of pulp are:

- Odontoblastic layer at the pulp periphery.
- Cell free zone of Weil.
- Cell rich zone.
- Pulp core.

Odontoblastic layer. Odontoblasts consist of cell bodies and cytoplasmic processes. The odontoblastic cell bodies form the odontoblastic zone whereas the odontoblastic processes are located within predentin matrix. Capillaries, nerve fibers (unmyelinated) and dendritic cells may be found around the odontoblasts in this zone.

Cell free zone of Weil. Central to odontoblasts is subodontoblastic layer, termed cell free zone of Weil. It contains plexuses of capillaries and small nerve fiber ramifications.

Cell rich zone. This zone lies next to subodontoblastic layer. It contains fibroblasts, undifferentiated cells which maintain number of odontoblasts by proliferation and differentiation.

Pulp core. It is circumscribed by cell rich zone. It contains large vessels and nerves from which branches extend to peripheral layers. Principal cells are fibroblasts with collagen as ground substance.

Important features of the pulp:

1. Pulp is located deep within the tooth, so defies visualization.
2. It gives radiographic appearance as radiolucent line.
3. Normal pulp is a coherent soft tissue, dependent on its normal hard dentin shell for protection. Therefore, once exposed, it is extremely sensitive to contact and temperature but this pain does not last for more than 1–2 seconds after the stimulus is removed.
4. Pulp is totally surrounded by dentin which limits the area for expansion and restricts the pulp's ability to tolerate edema.
5. Pulp has almost total lack of collateral circulation, which severely limits its ability to cope with bacteria, necrotic tissue and inflammation.
6. Pulp consists of unique cells, the odontoblasts, as well as cells that can differentiate into hard-tissue secreting cells. These cells form dentin and/or irritation dentin in an attempt to protect pulp from injury.
7. Pulpal responses are unpredictable.
8. The innervation of pulp tissue is both simple and complex. Simple in that there are only three nerve endings and consequently the pulp lacks proprioception. Complex because of innervation of the odontoblast processes which produces a high level of sensitivity to thermal and chemical changes.
9. Correlation of clinical signs and symptoms with corresponding specific histological Figure is often difficult.

Pulpitis is a condition in which the pulp (nerve) of the tooth becomes inflamed, causing pain and pressure in the tooth. There are varying degrees of pulpitis, from mild to severe (S. Watson, 2014).

When the pulp becomes inflamed, pressure in the pulp chamber affects the nerve and connective tissue in the tooth. Extreme cases of pulpitis may result in a phenomenon called referred pain, causing pain from pulpitis to be detected in unrelated areas of the face and mouth, ultimately making it difficult for the patient and the dentist to pinpoint the exact tooth causing the pain.

Pulpitis is inflammation of dental pulp tissue. Pulpitis is mainly caused by bacteria infection which itself is a secondary development of caries (tooth decay). It manifests itself in the form of a toothache.

Question 2. Etiological factors of the pulpitis development.

The etiology of pulpitis are:

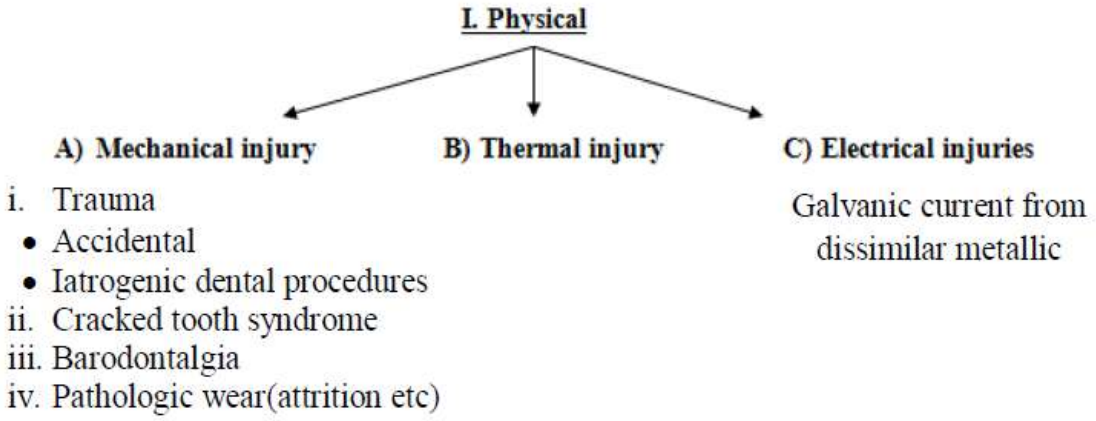
I. Physical

II. Chemical

a) Phosphoric acid, acrylic monomer
b) Erosion (Acids)

III. Bacterial

1. Toxins associated with caries.
2. Direct invasion of pulp from caries or trauma.
3. Microbial colonization in the pulp by blood borne microorganisms (Anachoresis)



A) Mechanical injury

I. Trauma:

1. Traumatic injury may or may not be accompanied by fracture of the crown or root.
2. More in children than in adults.
3. Habits such as
   - ✓ Opening bobby pins with the teeth,
   - ✓ Compulsive bruxism,
   - ✓ Nail biting etc.
4. In addition certain dental procedures occasionally injure the pulp:
   - ✓ Exposure of the pulp during excavation of carious tooth structure.
   - ✓ The use of pins for mechanical retention of amalgam or other restoration.
   - ✓ Malleting of gold-foil filling without adequate cement base.
   - ✓ Rapid separation of teeth by means of a mechanical separator.
   - ✓ Too-rapid movement of the teeth during orthodontic treatment.

Question 3. Pathogenetic aspects of the pulpitis development.

Immune Response. Pulpitis is characterized as the immune and neurological responses that are mainly triggered by the invasion of caries-related microorganisms into dentinal tubules and pulp. Pulp reacts to various irritants as do other connective tissues. Degree of inflammation is proportional to intensity and severity of tissue damage. For example, slight

irritation like incipient caries or shallow tooth preparation causes little or no pulpal inflammation, whereas extensive operative procedures may lead to severe pulpal inflammation.

In the pulp, just as in other areas of the body, inflammation can be present. Inflammation of the pulp does not take place only when the bacteria in the decay have reached the pulp. Bacterial products may reach the pulp much earlier and begin the inflammatory response. The inflammation may be acute or chronic because just like other tissues in the body, the pulp will react to irritants with innate and/or adaptive immune responses.

Innate immunity in the pulp is not specific but uses receptors to recognize molecular patterns common to microbes to initiate bacterial killing (phagocytosis). The components of the innate response of the dentin/pulp complex to caries include at least the following six:

1) outward flow of dentinal fluid;

2) odontoblasts;

3) neuropeptides and neurogenic inflammation;

4) innate immune cells, including immature dendritic cells (DCs), natural killer (NK) cells, and T cells, as well as

5) their cytokines and

6) chemokines.

Although the first two items are not classic components of innate immunity, they are uniquely involved in the initial inflammatory response to caries. Odontoblasts, (the cells that form dentin) have cellular processes that extend into dentinal tubules and are the first to encounter the caries bacterial antigens. They express low levels of interleukin 8 (IL-8) and genes related to chemokines and chemokine receptors. The odontoblasts have been shown to attract immature dendritic cells.

Dendritic cells (DCs) are a heterogeneous leukocyte (white blood cell) population. DCs in healthy peripheral tissues (steady state) are in an immature state. The cells are capable of sensing microbes as well as antigen capture and processing capabilities. A rapid accumulation of pulpal DCs has been observed beneath cavity preparations, and an increased number of DCs accumulated under pulpal immune response.

Persistent infection leads to the activation of adaptive immunity. A transition to an adaptive immune response will take place in the dental pulp as caries and bacteria approach the pulp. Antigens are recognized individually and lines of lymphocytes are developed to produce specific antibodies which attach to the recognized cells and initiate their destruction. Phagocytes remove the remains. B cells and T cells are the major lymphocytes involved.

A variety of cytokines have been observed in the pulp. Patients with symptomatic and asymptomatic irreversible pulpitis have been shown to have

an almost 23-fold increase in the cytokine IL-8 in the pulp. Cytokines in the pulp interact with each other. The ultimate effect on pulpal inflammation and healing is dependent upon the integrated actions of these inflammatory mediators. In addition to the lymphocytes, macrophages also provide defense against certain intracellular pathogens. Activated macrophages can function as class II antigen-presenting cells, similar to pulpal dendritic and B cells. In addition, activated macrophages secrete many inflammatory mediators.

Macrophages in the pulp become activated after receiving two signals. The first is a priming stimulus and the second is an activating signal. The priming stimulus is secreted by activated T-helper cells. The activating stimulus may include bacterial lipopolysaccharides, muramyl dipeptide, and other chemical mediators. Macrophages are professional phagocytes in innate immune responses. Activated macrophages are effective killers that eliminate pathogens in both innate and adaptive immune responses, and are also important in tissue homeostasis, through the clearance of senescent cells, and in remodeling and repair of tissue after inflammation. The number of macrophages increases with the progression of caries and is always higher than that of DCs at all stages of the caries invasion.

Neurological Response. According to the Brännström's hydrodynamic theory, activated nociceptors from fluid movement and other irritants through the patent dentine tubules result in pulp pain. Unmyelinated, slow conducting C-fibers aid in feeling a slowset, burning pain. According to neuronal studies, 70–80 % of pulpal axons are unmyelinated. Highly myelinated Aδ-fibers, which allow for fast conduction, are responsible for the sharp, shooting paining. Thus, the stimulus intensities are based on various fibers. Fast-conducting A β and Aδ-fibers provide the lowest stimulus intensities (typically referred to as prepain sensations), and those sensations eventually receive higher stimulation levels. The dull aches are associated with C-fibers and slow Aδ-fibers. As inflammation intensities, the A-fibers are increasingly activated. C-fiber innervation and Aδ-fibers are polymodal receptors that are sensitive to capsaicin and inflammatory mediators.

The pain mechanisms associated with pulpitis are similar to those of the rest of the body (i. e. receptors, intracellular signaling, transmitters, etc.). The inflammatory mediators act on specific receptors relating to nociceptive neurons, leading to the production of second messengers and activation of phospholipases and protein kinases. The second messengers regulate receptors ion channels that deal with sensitization. The ion channels open based on pain stimuli propagating action potentials in sensory neurons. In addition, dental caries is more likely to develop pulpitis due to less time for the dental pulp to react and protect itself by occluding the dentinal tubules. Based on the tooth injury, sensory nerve fibers react to pulpitis by growing terminal branches into the adjacent surviving pulp, which also changes the

cytochemical phenotype. This neural growth typically lasts a few days and function and form is retained. Thus, pain is poorly localized, and the level of pain stemming from pulpitis varies based on severity, quality, duration, onset, trigger. Thus, depending on condition of pulp, severity and duration of irritant, host response, pulp may respond from mild inflammation to pulp necrosis. These changes may not be accompanied by pain and thus may proceed unnoticed.

Pulpal reaction to microbial irritation:

1. Carious enamel and dentin contain numerous bacteria.
2. Bacteria penetrate in deeper layers of carious dentin.
3. Pulp is affected before actual invasion of bacteria via their toxic byproducts.
4. Byproducts cause local chronic cell infiltration.
5. When actual pulp exposure occurs, pulp tissue gets locally infiltrated by PMNs to form an area of liquefaction necrosis at the site of exposure.
6. Eventually necrosis spreads all across the pulp and periapical tissue resulting in severe inflammatory lesion.

Degree and nature of inflammatory response caused by microbial irritants depends on:

1. Host resistance.
2. Virulence of microorganism.
3. Duration of the agent.
4. Lymph drainage.
5. Amount of circulation in the affected area.
6. Opportunity of release of inflammatory fluids.

Theories of Pulpitis

The traditional theory which explained the pulpal inflammation was referred to as strangulation theory.

Strangulation theory. On irritation, there is local inflammation in pulp, which results in vasodilatation, increased capillary pressure and permeability. These result in increased filtration from capillaries into tissues, thus increased tissue pressure. By this, thin vessel walls get compressed resulting in decreased blood flow and increased venous pressure. This results in vicious cycle, because increase in venous pressure further increases capillary pressure. Consequently, choking/strangulation of pulpal blood vessels occurs because of increased tissue pressure. This results in ischemia and further necrosis.

Current theory. Many studies have shown that increase of pressure in one area does not affect the other areas of pulp. Therefore local inflammation in pulp results in increased tissue pressure in inflamed area and not the entire pulp cavity. It is seen that injury to coronal pulp results in local disturbance,

but if injury is severe, it results in complete stasis of blood vessels in and near injured area. Clear absorption of fluid into capillaries in adjacent uninflamed area results in increased lymphatic drainage thus keeping the pulpal volume almost constant.

Limited increase in pressure within affected pulpal area is explained by the following mechanism:

i. Increased pressure in inflamed area favors net absorption of interstitial fluids from adjacent capillaries in uninflamed tissues.
ii. Increased interstitial tissue pressure lowers the transcapillary hydrostatic tissue pressure difference, thus opposes further filtration.
iii. Increased interstitial fluid pressure increases lymphatic drainage.
iv. Break in endothelium of pulpal capillaries facilitates exchange mechanism.

Infectious sequelae of pulpitis include apical periodontitis, periapical abscess and osteomyelitis of the jaw. Spread from maxillary teeth may cause purulent sinusitis, meningitis, brain abscess, orbital cellulitis, and cavernous sinus thrombosis. Spread from mandibular teeth may cause angina, parapharyngeal abscess, mediastinitis, pericarditis and empyema.

Question 4. Classifications of pulpitis.

Table 5. **Classifications of pulpitis**

International classification ICD-10	**K 04 Diseases of pulp and periapical tissues** **K04.0 Pulpitis** K04.00 Initial (hyperaemia) K04.01 Acute K04.02 Suppurative [pulpal abscess] K04.03 Chronic K04.04 Chronic, ulcerative K04.05 Chronic, hyperplastic [pulpal polyp] K04.08 Other specified pulpitis K04.09 Pulpitis, unspecified **K04.1 Necrosis of pulp** Pulpal gangrene **K04.2 Pulp degeneration** Denticles Pulpal calcification Pulpal stones **K04.3 Abnormal hard tissue formation of pulp**

	K04.3X Secondary or irregular dentine ***Excludes***: pulpal calcifications (K04.2) pulpal stones (K04.2)
Pulpitis classification (E. M. Gofung, 1928)	1. Acute pulpitis: a. Partial. b. General. c. Purulent. 2. Chronic pulpitis: a) Fibrous (simple). b) Hypertrophic. c) Gangrenous.
American Association of Endodontists Classification	− Normal pulp − Reversible pulpitis − Symptomatic irreversible pulpitis − Asymptomatic irreversible pulpitis − Pulp necrosis − Previously treated − Previously initiated therapy
Grossman's Clinical Classification	**1. Pulpitis: inflammatory disease of dental pulp.** a. Reversible papulosis: − Symptomatic (Acute). − Asymptomatic (Chronic). b. Irreversible pulpitis: • Acute − Abnormally responsive to cold. − Abnormally responsive to heat. • Chronic – Asymptomatic with pulp exposure. – Hyperplastic pulpitis. – Internal resorption. **2. Pulp degeneration**: a. Calcific (Radiographic diagnosis). b. Other (Histopathological diagnosis). **3. Pulp necrosis**: a. Coagulation necrosis. b. Lique faction necrosis.
Ingle's Classification	**1. Inflammatory changes**: a. Hyperreactive pulpalgia. − Hypersensitivity. − Hyperemia. b. Acute pulpalgia.

	– Incipient. – Moderate. – Advanced. c. Chronic pulpalgia. d. Hyperplastic pulpitis. e. Pulp necrosis. **2. Retrogressive changes**: a. Atrophic papulosis. b. Calcific papulosis.
Baume's Classification	Based on clinical symptoms: – Asymptomatic, vital pulp which has been injured or involved by deep caries for which pulp capping may be done. – Pulp with history of pain which is amenable to pharmacotherapy. – Pulp indicated for extirpation and immediate root filling. – Necrosed pulp involving infection of radicular dentin accessible to antiseptic root canal therapy.
Seltzer and Bender's Classification	Based on clinical tests and histological diagnosis: 1. Treatable without pulp extirpation and endodontic treatment: – Intact uninflamed pulp. – Transition stage. – Acute pulpitis. – Chronic partial pulpitis without necrosis. 2. Untreatable without pulp extirpation and endodontic treatment: – Chronic partial pulpitis without necrosis. – Chronic total pulpitis. – – Total pulp necrosis.

Tests to the topic

1. The main cause of the pulpitisis:

a. Micro-organisms and their toxins.
b. Disturbance in the body's immune system.
c. Tooth injury.

d. Periodontal tissue disease.
e. General somatic diseases.

2. Iatrogenic pulp can result from:

a. Tooth overheating when violation of the preparation of hard tissues.
b. Enamel hypoplasia.
c. Excessive working depth in the formation of cavities.
d. Erosion of enamel.
e. Accidental removal parapulparnal pin in the tooth cavity.

3. Severe pain in acute pulpitis occurs due to:

a. An increase in hydrostatic pressure in the cavity of the tooth.
b. Stimulation of the nerve endings of the products of anaerobic glycolysis.
c. An increase in the amount of bradykinin.
d. A decrease in hydrostatic pressure in the cavity of the tooth.
e. A decrease in the number of vasoactive substances.

4. Which of the following classifications reflect the clinical and pathological-anatomical aspects?

a. The ICD-10.
b. E.M. Gofung.
c. MMSI.
d. Classification CIU.
e. Classification E.E. Platonov.

5. To "chronic pulpitis" according classification of E.M. Gofung includes:

a. A simple.
b. Hypertrophic.
c. Gangrenous.
d. Purulent.
e. Fibrous.

6. By the chemical factors of occurrence of pulpitis include:

a. The treatment cavity alcohol and ether.
b. Unlined sealing.
c. The effects of traumatic curettage of periodontal pockets.
d. Diffusion of the monomer into the pulp.
e. Work without interruption boron and cooling.

7. Degree and nature of inflammatory response caused by microbial irritants depends on:

a. Host resistance.
b. Virulence of microorganism.
c. Duration of the agent.
d. Lymph drainage.
e. Amount of circulation in the affected area.
f. Opportunity of release of inflammatory fluids.
g. All of the above

8. The components of the innate response of the dentin/pulp complex to caries include:

a. Outward flow of dentinal fluid.
b. Odontoblasts.
c. Neuropeptides and neurogenic inflammation;
d. Innate immune cells, including immature dendritic cells (dcs), natural killer (NK) cells, and T cells, as well as their cytokines and chemokines.
e. All of the above.

9. Zones of pulp are:

a. Odontoblastic layer at the pulp periphery.
b. Cell free zone of Weil.
c. Cell rich zone.
d. Pulp core.
e. All of the above.

10. Composition of the pulp are:

a. Cells.
b. Matrix.
c. Blood vessels.
d. Lymphatics.
e. Nerves.
f. All of the above.

LESSON 6. ACUTE PULPITIS. CLINICS, DIAGNOSTIC METHODS

Question to be studied at the classes

1. Overview of the Pulp–Dentine Complex.
2. Diagnostic Terminology Approved by the American Association of Endodontists and the American Board of Endodontics: Reversible Pulpitis and Irreversible Pulpitis.
3. Comparison of different classifications
4. Clinical manifestations of acute pulpitis.
5. Purulent pulpitis [pulp abscess] (DIC-10, 1997). Acute purulent pulpitis (Gofung, 1927). Clinical appearance.
6. Diagnostics of acute pulpitis. Differential diagnostics of acute pulpitis.

Question 1. Overview of the Pulp–Dentine Complex

The dental pulp is a specialized connective tissue entirely enclosed by dentine consisting of the pulp periphery and pulp proper. The peripheral pulp can be distinguished into three further zones including the pseudo stratified layer of the highly differentiated dentine producing odontoblast cells, a subodontoblastic 40-μm cell-free zone and a cell-rich zone. The terminal branches of the sensory and autonomic nerve fibres are located in the sub-odontoblastic zone. The central pulp core consists of mainly fibroblasts, collagen and elastin fibres, large blood vessels and nerve bundles. The entire pulp is embedded in a gel-like ground substance. The odontoblasts are responsible for production of mineralised dentine. Dentine is permeated by millions of tubules each containing a cellular process from an odontoblast. In a fully developed tooth, the dentinal tubules have a diameter of 3 μm at the outer periphery of dentine with a density of approximately 15,000/mm 2. As the dentinal tubules converge towards the pulp, they are more closely packed together with diameters reducing to 1 μm with a density of 65,000/mm 2. The pulp–dentine complex has the ability to respond to microbiological, mechanical, thermal or chemical stimuli and insults, which are responsible for inflammation within the pulp. Mild insults may result in increased dentinogenesis as a means of a protective mechanism whereby increased peritubular dentine formation responsible for the formation of sclerotic dentine can occur. Tertiary dentine, either reactionary or reparative in origin, can also be formed in response to dentine injuries or toxic products that reach the pulp–dentine complex. Reactionary dentine, typically produced by pre-existing odontoblasts, may be a response to a freshly cut cavity or a response to the restorative interface. Newly differentiated odontoblastoid cells, on the other hand, form reparative dentine, when the primary odontoblast is irreversibly damaged. Growth factors such as transforming growth factor-β are responsible for the initiation of odontoblast differentiation and

stimulation of dentine formation. Release of growth factors typically occurs during carious attacks to the tooth and injuries sustained following cavity preparation and subsequent restoration of the tooth.

Progression of pulpal pathologies

Pulp reacts to above mentioned irritants as do other connective tissues. Degree of inflammation is proportional to intensity and severity of tissue damage. For example, slight irritation like incipient caries or shallow tooth preparation cause little or no pulpal inflammation, whereas extensive operative procedures may lead to severe pulpal inflammation. Depending on condition of pulp, severity and duration of irritant, host response, pulp may respond from mild inflammation to pulp necrosis. These changes may not be accompanied by pain and thus may proceed unnoticed.

Pulpal reaction to microbial irritation

Carious enamel and dentin contains numerous bacteria

↓

Bacteria penetrate in deeper layers of carious dentin

↓

Pulp is affected before actual invasion of bacteria via their toxic byproducts

↓

Byproducts cause local chronic cell infiltration

↓

When actual pulp exposure occurs pulp tissue gets locally infiltrated by PMNs to form an area of liquefaction necrosis at the site of exposure

↓

Eventually necrosis spreads all across the pulp and periapical tissue resulting in severe inflammatory lesion.

Question 2. Diagnostic Terminology Approved by the American Association of Endodontists and the American Board of Endodontics. Reversible Pulpitis and Irreversible Pulpitis

The histological state of the pulp cannot be assessed clinically. Nevertheless, the signs and symptoms associated with progressive pulpal disease can give a reasonable indication of the likely state of an inflamed pulp, that is whether it is reversibly or irreversibly damaged.

Reversible Pulpitis (Hyperemia) is based upon subjective and objective findings indicating that the inflammation should resolve and the pulp return to normal following appropriate management of the etiology. This is the first stage where the pulp is symptomatic. There is a sharp hypersensitive response to cold, but the pain subsides when stimulus is removed. The patient may describe symptoms of momentary pain and is unable to locate the source of pain. This stage can last for month or years.

Etiology. Pulpal irritation to external stimuli is related to dentin permeability. Under normal circumstances, enamel and cementum act as impermeable barrier to block the patency of dentinal tubules at dentinoenamel junction or dentinocemental junction.

When caries and operative procedures interrupt this natural barrier, dentinal tubules become permeable. So inflammation can be caused by any agent which is capable of injuring pulp.

It can be:

1. *Trauma*. Accident or occlusal trauma.
2. *Thermal injury*. While doing tooth preparation. Overheating during polishing of a restoration
3. *Chemical stimulus*. Like sweet or sour foodstuff
4. *Following insertion of a deep restoration*.

Irritation of the pulp causes inflammation, and the level of response will depend on the severity of the irritant. If it is mild, the inflammatory process may resolve in a similar fashion to that of other connective tissues; a layer of reparative dentine may be formed as protection from further injury. However, if the irritation is more severe, with extensive cellular destruction, further inflammatory changes involving the rest of the pulp will take place, which could eventually lead to total pulp necrosis.

There are features of pulpitis which can make the borderline between reversible and irreversible pulpitis difficult to determine clinically. In general, if the responses to several tests are exaggerated, then an irreversible state is possible.

The essential feature of a reversible pulpitis is that pain ceases as soon as the stimulus is removed, whether it is caused by hot or cold fluids, or sweet food. The teeth are not tender to percussion, except when occlusal trauma is a factor.

Symptoms. Sensitivity/pain to hot, cold or sweet with immediate onset. Pain is usually sharp and may be difficult to locate. Quickly subsides after removal of the stimulus.

Signs. Exaggerated response to pulp testing. Carious cavity/leaking restoration. Tooth not tender to percussion.

Histopathology. Reversible pulpitis is the general category which histologically may represent a range of responses varying from dentin hypersensitivity without concomitant inflammatory response to an early phase of inflammation."

Reversible pulpitis may range from hyperemia to mild-to moderate inflammatory changes limited to area of involved dentinal tubules. It shows:

1. Increased blood volume of pulp associated with increased intrapulpal pressure.

2. Edema of tissue.
3. White cell infiltration.
4. Reparative dentin formation.

To summarize, therefore, in reversible pulpitis:

1) The pain is of very short duration and does not linger after the stimulus has been removed.
2) The tooth is not tender to percussion.
3) The pain may be difficult to localize.
4) The tooth may give an exaggerated response to vitality tests.
5) The radiographs present with a normal appearance, and there is no apparent widening of the periodontal ligaments.

Should the symptoms persist and the level of pain increase in duration and intensity, then the pulpitis is likely to be irreversible.

Threshold to pain decreases in reversible pulpitis.

It may be attributed to:

- Release of mediators (endogenous alogenic agents) which initiate or lower the threshold of excitability.
- Neuropeptides released from unmyelinated C fibers mediate neurogenic inflammation which results in hyper excitability of nerve endings.

Diagnosis

1. *Pain*: it is sharp but of brief duration, ceasing when irritant is removed.
2. *Visual examination and history*: It may reveal caries, traumatic occlusion and undetected fracture.
3. *Radiographs*: these show normal PDL and lamina dura.
   - Depth of caries or restoration may be evident
4. *Percussion test:* it shows negative responses, i.e. tooth is not tender to percussion.
5. *Vitality test*: pulp responds readily to cold stimuli. Electric pulp tester requires less current to cause pain.

Symptomatic Irreversible Pulpitis is based on subjective and objective findings that the vital inflamed pulp is incapable of healing and that root canal treatment is indicated. Characteristics may include sharp pain upon thermal stimulus, lingering pain (often 30 seconds or longer after stimulus removal), spontaneity (unprovoked pain) and referred pain. Sometimes the pain may be accentuated by postural changes such as lying down or bending over and over-the-counter analgesics are typically ineffective. Teeth with symptomatic irreversible pulpitis may be difficult to diagnose because the inflammation has not yet reached the periapical tissues, thus resulting in no pain or discomfort to percussion. In such cases, dental history and thermal testing are the primary tools for assessing pulpal status.

Acute Inflammation: Effects of Nerve Factors with Tissue Injury Factors

- ✓ Vasodilatation.
- ✓ Increase pressure.
- ✓ Secondary pain response.
- ✓ Mechanism of pulp acute inflammatory response.
- ✓ Vascular changes at injury site due to cellular and neurogenic response.

Pulp injury is frequently irreversible and painful because of certain restrictions in its environment:

1. Pulp surrounded by hard, stubborn tissue
2. Ineffective collateral circulation.

Characteristic of pulpal pain is that the patient is unable to localize the affected tooth but the pain does not cross the midline. The ability of the pulp to recover from injury depends upon its blood supply, not the nerve supply, which must be borne in mind when vitality (sensibility) testing is carried out. It is impossible to reliably achieve an accurate of the state of the pulp on clinical grounds alone; the only 100% accurate method is histological section.

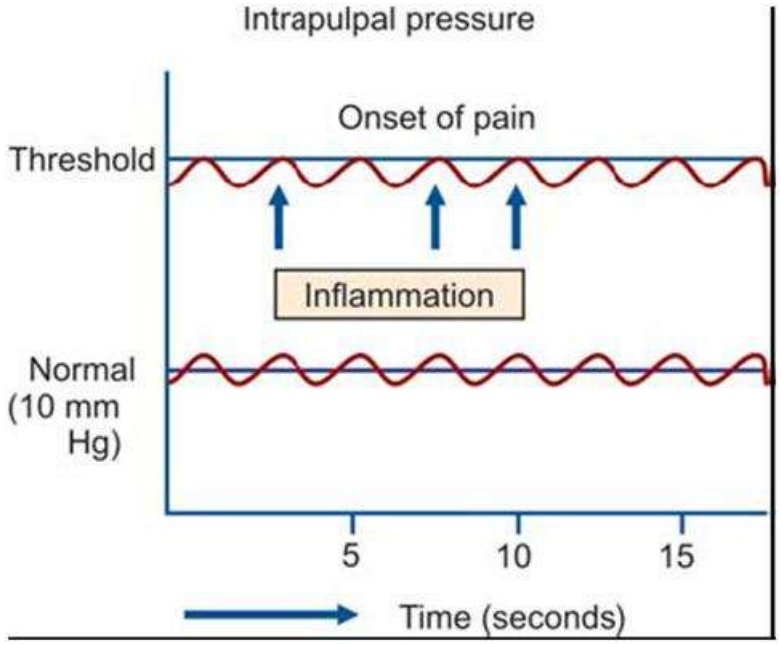


Figure2. Increased intrapulpal pressure causing pulpal pain

Table6.**Differential diagnosis of reversible and irreversible pulpitis**

Features	***Reversible pulpitis***	***Irreversible pulpitis***
1. Pain type	Sharp and fleeting pain, usually dissipates after stimulus is removed	Intense, continuous and prolonged pain due to pressure of secondary irritants
2. Stimulus	External stimulus, for example - heat, cold, sugar	− No external stimulus − Dead or injured pulp

		tissue acts as secondary stimulant.
3. Pain at night/postural	No	Yes
4. Pain localization	Only with applied cold stimulus or PDL inflammation	Only with applied heat stimulus or PDL inflammation.
5. Referred pain	Not usually found	Common finding
6. History	− Any history of recent dental procedure done − Sometimes cervicalerosion/abrasion	− Deep carries − Trauma − Extensive restoration
7. Percussion/Occlusion	If due to occlusion, percussion test is positive, otherwise normal.	If PDL is involved, percussion test is positive, otherwise normal
8. Pulp tests a. EPT	Normal response	Normal to elevated response
b. Cold	Exaggerated response	Pain relieved by cold occasionally
c. Heat	Normal-exaggerated response	Acute Pain
9. Color change	No	Yes
10. Radiograph	Caries, defective or restoration without pulp protection	Caries, defective restorations, PDL space enlargement
11. Treatment	Removal of decay, repair of defective restoration, ZOE dressing, occlusal adjustment	Pulpectomy (single root), Pulpotomy (multiple roots), occlusal adjustment

Question 3. Comparison of different classifications

Although numerous classifications of pulpal disease exist, only limited number of clinical diagnostic situations require identification before effective treatment can be given.

Acute pulpitis (DIC-10, 1997). Acute partial pulpitis, Acute general pulpitis (Gofung, 1927).

In the International Classification (DIC-10, 1997), the initial and subsequent phases of acute inflammation of the dental pulp are not separated and united in a single diagnosis of "acute pulpitis".

The initial phase of acute inflammation of the pulp is "acute partial pulpitis". The focus of inflammation is localized in the area of pulp, most closely adjacent to the carious cavity. Therefore often inflammatory process begins in the area of the horn of the pulp. Duration of the disease is not more than 2 days.

The patient complains of intense pain from all types of pain irritants which persist even after the removal of irritants. Pain attack can also occur

spontaneously - without affecting of apparent reason. In early disease the frequency and duration of pain episodes is unstable, they can last 10-30 minutes, in most cases less than one hour.

Pain attack is replaced by a sufficiently long painless period which lasts several hours. Patients usually correctly points to disturbing tooth, which indicates the absence of pain irradiation. At night, the pains are more intense.

With further development of acute pulpitis patients complained of long-term pain attacks with small painless intervals lasting no more than 30-40 minutes, night pain, pain, growing in the "lying", as well as long-term pain caused by irritants. The duration of pain is from 2 to 5 days. The patient may be unable to decide which tooth is causing the problem, since the pain is often referred to teeth in both the upper and lower jaw on the same side. The patient can not specify the aching tooth, as the pain is not localized, and radiates through the branches of the trigeminal nerve: in case of pulpitis upper jaw teeth- in a temple, superciliary and malar area, into the teeth of the lower jaw; in case of pulpitis of lower jaw teeth - in a nape, ears, submandibular area, in the temple, in the teeth of the upper jaw. For anterior teeth pulpitis irradiation of the pain on the opposite side of the jaw is possible. Deterioration of general condition is possible.

On examination a deep carious cavity with plenty of softened dentin is defined. Probing the bottom of the carious cavity is sharply painful at the point adjacent to the horn of the pulp. There is no connection with the cavity of the tooth. Percussion of a tooth is painless. Palpation of transitional fold in the projection area of the root apex is painless.

Question 4. Clinical manifestations of acute pulpitis. Common features.

Acute forms of pulpitis are characterized by the following symptoms:

1. Acute pain. Pain sensation achieves significant force, becomes unbearable.

2. “Spontaneous” pain - pain which occurs regardless of external stimules. The intensity of the pain attack, its frequency depends on the severity of the clinical course of inflammatory process. Until now it is a Question , with what pain in case of acute pulpitis is connected, why it is usually impermanent and disappears as suddenly as it appeared.

In the literature, the reasons of spontaneous pain include: circulatory disorders, irritation of the nerve endings by bacterial toxins and products of decay of organic dentin and pulp substances, pH changes in the zone of inflammation.

Pain syndrome may be the result of external factors influence or changes in pulp caused by vasoactive mediators of inflammation. The pain-producing inflammatory mediators may have a direct effect on the nerve fibers, causing pain, and may indirectly influence, lowering the threshold of

pain sensitivity and thereby increasing the level of pain response to external stimules.

Acute pulpitis pain symptom is associated with the activity of slow-reacting nerve C - fibers in the dental pulp, in contrast to the manifestations of tooth hypersensitivity which is associated with stimulation of responsive nerve fiber-A in the pulp.

3. Functioning of stimules (mechanical, chemical and thermal) leads to prolonged pain attack that remains for some time even after the removal of the stimulus. External stimulation is only provoking agent of pain attack. The duration of the attack is determined not only by the strength of the stimulus, but by reactive properties of the inflamed pulp, depending on the location of the lesion, the nature of the infection and others.

Pain responses in case of pulpitis usually occurs due to exposure of very weak stimules. Thus, if a healthy pulp takes heat at 50-60° C and feels cold at 15-20° C, the range of temperature variation, which corresponds to inflammation of the pulp is significantly narrowed, and the water temperature of 28-30° C already causes pain.

4. Pain at night. Pain often appears during sleep.

5. Paroxysmal nature of pain with pain-free intervals. The duration and frequency of pain attacks and painless periods (intermission) are in a certain connection with each other. In the initial stage of acute pulpitis short attacks of spontaneous pain are stated (from a few minutes to 1-2 hours) and prolonged painless intervals (for hours and days). With the spread of the inflammatory process, duration and frequency of pain attacks is gradually growing. However, in case of prolonged attacks pain, there are intervals between attacks in any form of pulpit.

This alternation is probably due to the adaptive capacity of the body to the perception of long-term pain, exhausting of nervous system, periodic compression of the nerve receptors resulting in edema of the pulp, and so on. Sometimes in pain bouts there is hypersensitivity of certain areas of the face and neck, corresponding to the affected teeth. Hypersensitivity of Ged zones in cases of acute pulpitis occurs in 65-67% of cases. Often the pain irradiates along the branches of the trigeminal nerve.

Question 5. Purulent pulpitis [pulp abscess] (DIC-10, 1997). Acute purulent pulpitis (Gofung, 1927). Clinical appearance.

Acute purulent pulpitis usually develops from acute pulpitis, it is an abscess in the tooth cavity.

Purulent pulpitis characterized by sudden severe spontaneous, throbbing pain. Pain often irradiates along the branches of the trigeminal nerve. The pain attack gradually increases and becomes throbbing. The pain interrupts or partially weakens for a few minutes (remission) and then

resumes again. The pain is more intensive at night. Effect of heat irritants (above 35C) increases the strength of the attack. Irritation of the cold water reduces intensity of pain in some extent.

Examination reveals the deep carious cavity with the softened dentin. Pulp chamber of the teeth is usually closed. Probe or excavator easy perforate pulp chamber of the teeth, it is possible to identify a drop of pus, and then the blood. Deep probing of pulp chamber is painful. After the opening of pulp chamber the tooth pain attacks become less strengthen or disappear. Percussion of the teeth is extremely painful. Data of electric pulp test are 40-50 mA.

Microscopic study reveals a significant accumulation of pulp exudate, there is the accumulation of white blood cells and the formation of abscesses. Vessels expanded all over, stasis of capillaries, Figure of diffuse of purulent inflammation of the pulp tissue. The development process is accompanied by melting the tissue at sites of multiple small abscess formation. There is the accumulation of microorganisms in the center of abscess.

Question 6. Diagnosis of acute pulpitis. Differential diagnosis of acute pulpitis.

Basic methods of examination. On examination the deep carious cavity is defined. The probing is acutely painful around the bottom. There is no connection with the cavity of a tooth. Vertical percussion can be a little painful. All kinds of irritants (cold, heat) cause pain increase. Temperature irritants cause intense pain attack which continues for a long time and is slow.

Additional methods of examination. According to the X-ray carious cavity adjacent to the tooth cavity is often defined. There are no changes in periodontal root apex. X-ray research is carried out to determine the localization of the cavity, if it is on the contact surface and it is not possible to detect it by probing. Radiography is also advisable to identify the other closed for examination lesions that can cause inflammation of the pulp (periodontal pocket, the focus of inflammation in periapical tissues, etc.).

1. Visual examination and history: examination of involved tooth may reveal previous symptoms. On inspection, one may see deep cavity involving pulp or secondary caries under restorations.

2. Radiographic findings:

- May show depth and extent of caries.
- Periapical area shows normal appearance but a slight widening may be evident in advanced stages of pulpitis.

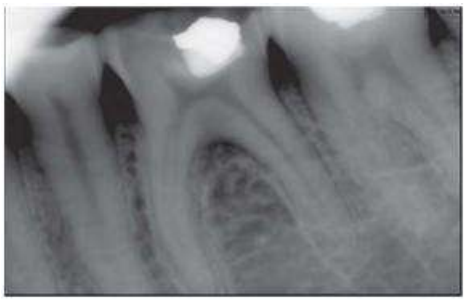


Figure 3. Deep restoration approximating the pulp in mandibular molars

Figure 4. Carious exposure of pulp in second premolar and first molar

3. Percussion: tooth is tender on percussion (due to increased intrapulpal pressure as a result of exudative inflammatory tissue).

4. Vitality tests.

Thermal test: hyperalgesic pulp responds more readily to cold stimulation than for normal tooth, pain may persist even after removal of irritant. As the pulpal inflammation progresses, heat intensifies the response because it has expansible effect on blood vessels. Cold tends to relieve pain because of pressure.

There are several different types of cold thermal tests available to the clinician, which vary in the degree of cold being applied. Simple ice sticks can be made in the dental surgery by freezing water in non-contaminated or disinfected local anaesthetic needle sheaths. The ice stick can be removed from the freezer when required, run under water to separate from the sheath and applied directly to the tooth using gauze.

Ethyl chloride (boiling point −4 °C) can be sprayed on to a cotton pledget resulting in the formation of ice crystals; it is then applied to the tooth. Dichlorodifl uoromethane (DDM) (boiling point –50°C) is a compressed refrigerant spray, which can similarly be sprayed on to a cotton pledget and applied to the tooth under investigation.

Another effective method of applying cold is using carbon dioxide (CO_2) snow (boiling point -72°C), which is particularly useful when attempting to assess teeth with full gold coverage metal restorations. The CO2 gas is released from a gas cylinder into a plastic plunger mechanism and compressed to produce a stick of CO2. By using a special applicator, it may then be applied to the tooth under investigation. Frictional heat may be generated by using a rubber cup intended for prophylaxis (without paste) against the buccal aspect of a tooth.

A gutta-percha stick may be heated with anaked flame or an electric heater until it becomes soft and glistens. This can then be applied to the tooth under investigation, which has been coated with Vaseline. A specialised system B tip can also be directly applied to the tooth under investigation.

Electric test: less current is required in initial stages. As tissue becomes more necrotic, more current is required.

Two widely used battery-operated electric pulp testers (EPT) are the Analytic Technology pulp tester and the Vitality Scanner (Analytic Sybron Dental Specialities, Orange, CA, USA). These monopolar pulp testers involve only one electrode, which is applied to the tooth. The patient completes the electric circuit by holding the metallic handle of the EPT, or a lip clip, which is applied to the patient's lower lip. They function by producing a pulsating electrical stimulus. The intensity automatically begins from a very low value to prevent unnecessarily excessive stimulation and discomfort. The intensity of the electrical stimulus steadily increases at a predetermined rate selected by the clinician. A note is made of the reading on the digital display when the patient acknowledges a warm or tingling sensation. The clinician should consider a response or no response as being the important finding, rather than the digital reading on the tester.

Tests require tooth isolation and conducting media. Tooth isolation using rubber dam during EPT is essential to prevent gingival conduction. Electric current can also be transferred between adjacent teeth through contacting metallic restorations. In these cases drying the enamel and the placement of a plastic strip interproximally and use of rubber dam can prevent electrical impulses from spreading across the surface of the tooth and to adjacent teeth. A conducting medium should be used to ensure that maximum current passes from the electrode to the tooth surface.

Data of Electric pulp test are from 30 to 40 mcA.

A response to EPT does not provide any information about the health status of the pulp, its integrity or circulation. It only indicates that some sensory fibres are present within the pulp tissue that are capable of responding to stimulus.

Pulp testing in older patients or teeth that have pulp canal obliteration may not respond. Endodontic treatment cannot be justified on the basis of these tests alone. The clinician must take into consideration other clinical and radiographic signs and symptoms which together with pulp vitality testing may correlate the true pulpal status.

Figure 5. Clinical photographs demonstrating (a) application of electric pulp testing (EPT) using the Analytical Technology pulp tester. (b) A lip clip is provided which the patient can hold or alternatively place in the inner aspect of the lip to complete the circuit

The use of EPT in combination with one of the commonly used cold pulp tests will provide more accurate results for the evaluation of pulp vitality rather than using one of these methods alone.

Acute pulpitis is differentiated from:

- ✓ Pulp hyperemia
- ✓ Acute apical periodontitis
- ✓ Trigeminal neuralgia
- ✓ Sinusitis
- ✓ Alveolar pain (alveolitis)
- ✓ Acute partial pulpitis differs from acute total pulpitis

Acute pulpitis differs from ***pulp hyperemia*** by spontaneous paroxysmal pains, worse at night, as well as prolonged pain response to external irritants.

Acute apical periodontitis is characterized by: a constant aching pain localized in the area of causative tooth, sharp pain when biting on an aching tooth, and pain on percussion. While examination - hyperemia and edema of transitional fold, pain on palpation in the projection of the apex. There is no reaction to temperature irritants in case of apical periodontitis, data of Electric pulp test are over 100 mcA.

Trigeminal neuralgia is characterized by paroxysmal sharp pain that arises when receiving food, conversation, touching the skin. At night, there is no pain, and if there is an attack at night, it is caused only by an accidental touch of blankets, pillows and other items to the patient's skin. The teeth may be intact.

Sinusitis is characterized by the following symptoms: deterioration of general condition, fever, headaches, difficulties while breathing and nasal purulent exudate, heaviness and distension in the area of the maxillary sinus when bending the head forward. X-rays of the sinuses is used for diagnosis.

In case of alveolitis - tooth extraction in history. There is no blood clot in the wells, and its walls are covered with gray bloom with a characteristic putrid odor. Palpation of the gums in the area of wells is sharply painful.

Acute partial pulpitis differs from acute **total pulpitis** that in case of acute partial pulpitis there are no radiating pains, pain attack is always less prolonged in comparison with the silent period. Acute total pulpitis is characterized by a painful response to percussion.

Features of patient assessment with pulp pathology.

Valuable information may be acquired by asking the patient specific questions about the symptoms:

1. How long have you had the pain?
2. When did you first notice the pain or discomfort?
3. Can you point to the tooth or area that bothers you?
4. Does it hurt to bite on the tooth or to the touch it?

5. Describe the pain: sharp or dull, throbbing, mild or severe, localized or radiating, pulsating, nagging, sudden, off and on, constant, getting better or worsening.
6. Does the tooth start hurting by itself or on its own?
7. Does it hurt most during the day or at night, and how long does it last?
8. What makes it hurt: hot, cold, sweets, chewing/biting, air, other?
9. Does the pain linger?
10. Have you taking anything to relieve the pain? If so, does it relieve the pain? For how long?

Tests to the topic

1. Time of the beginning of acute focal pulpitis does not exceed:

a. 2 days.
b. 5 days.
c. 10 days.
d. 14 days.

2. Iatrogenic pulpitis can result from:

a. Overheating of the tooth in case of violation of hard tissues preparation.
b. Enamel hypoplasiaexcessive working depth in the formation of cavities.
c. Enamel erosion.
d. Accidental removal of parapulpitis pin in the tooth cavity.
e. Caries.

3. Severe pain in acute pulpitis is caused by:

a. Increase of hydrostatic pressure in a tooth cavity.
b. Stimulation of nerve endings by the products of anaerobic glycolysis.
c. Increase of the amount of bradikinin.
d. Decrease of hydrostatic pressure in a tooth cavity.
e. Reduction of the number of vasoactive substances.

4. The pulsating nature of pain in case of acute pulpitis is caused by:

a. Increase of hydrostatic pressure in a tooth cavity.
b. Stimulation of nerve endings by the products of anaerobic glycolysis.
c. Periodic shunting of blood flow in arteriovenus anastomoses.

5. Spontaneous paroxysmal night pains with a long silent period arise in the following case of pulpitis:

a. Acute focal.
b. Acute diffuse.

c. Chronic fibrous.
d. Chronic gangrenous.
e. Chronic hypertrophic.

6. Spontaneous, paroxysmal, radiating along the branches of the trigeminal nerve pain at night with short silent intervals occurs when in case of pulpitis:

a. Acute focal.
b. Acute diffuse.
c. Chronic fibrous.
d. Chronic gangrenous.
e. Chronic hypertrophic.

7. Cavity probing in case of acute focal pulpitis is sharply painful:

a. At one point.
b. On the walls and bottom of the cavity.
c. On the enamel-dentine compound.

8. Cavity probing in case of acute diffuse pulpitis is sharply painful:

a. At one point.
b. At the bottom of cavity.
c. On the enamel-dentine compound.

9. Temperature trial in acute pulpitis:

a. Sharply painful.
b. Painful.
c. Painless.

10. Electroexcitability of pulp in inflammation:

a. Increases.
b. Reduced.
c. Remains unchanged.

LESSON 7. CHRONIC PULPITIS. CLINICAL APPEARANCE, DIAGNOSTIC METHODS

Questions to be studied at the classes

1. Chronic pulp, concept. Classification of chronic pulpitis.
2. Chronic pulpitis (ICD -10, 1997) (Chronic simple pulpitis, Gofung E.M., 1927).
3. Chronic hyperplastic pulpitis (DIC-10, 1997) (Chronic hypertrophic pulpitis Gofung E.M., 1927).
4. Chronic ulcerative pulpitis (DIC-10, 1997).
5. Pulp necrosis (DIC-10, 1997) (Chronic gangrenous pulpitis Gofung E.M, 1927).
6. Degeneration pulp (ICD-10, 1997).

Question 1. Chronic pulp, concept. Classification of chronic pulpitis.

Chronic pulpitis is an inflammatory response of pulpal connective tissue to an irritant. Here pain is absent because of diminished exudative inflammatory activity and corresponding decrease in intrapulpal pressure to a point below threshold limits of pain receptors.

Etiology is same as that of irreversible pulpitis. It is normally caused by slow and progressive carious exposure of pulp. Nature of pulpal response depends on strength and duration of irritant, previous health of pulp and extent of tissue affected.

Signs and Symptoms

- Pain is absent because of low activity of exudative forces. Here proliferative granulomatous forces dominate
- Symptoms develop only when there is interference with drainage of exudate
- Hyperplastic form of chronic pulpitis is seen in teeth of children and adolescents in which pulp tissue has high resistance and large carious lesion permit free proliferation of hyperplastic tissue. Since it contains few nerve fibers, it is non-painful but bleeds easily due to rich network of blood vessels.

The long duration is common to all forms of chronic pulpit - from several weeks to several months or even years, with mild subjective symptoms. In case of inaccessible cavity for the irritator pain symptom can be insignificant.

For all forms of chronic inflammation of the pulp is characterized by a pain, associated with the irritants that do not pass away after its removal during 30 minutes and more.

There are three basic forms of chronic inflammation of the pulp:

1. Chronic fibrous pulpitis;

2. Chronic hyperplastic pulpitis;
3. Chronic gangrenous (ulcerative) pulp.

Histopathology of chronic pulpitis

- Formation of sclerotic and irritation dentin
- Minimal amount of vasodilation and infiltration of cell, initially but when pulp is finally exposed, vasodilation and cellular infiltration increases
- Surface of pulp polyp is usually covered by stratified squamous epithelium which may be derived from gingiva, desquamated epithelial cells of mucosa and tongue.

Question 2. Chronic pulpitis (ICD-10, 1997) (Chronic simple pulpitis, Gofung E.M., 1927)

Patients complaints. There is pain in a tooth from different irritants (thermal, mechanical and chemical). Sharp changes in the ambient-temperature cause the pain. Spontaneous pain is absents. From history it becomes clear that the tooth previously pained.

Also there can be asymptomatic chronic pulpitis, when there are no complaints.

Basic methods of examination. Probing of carious cavity bottom is painful in one point. As a rule, the pulp chamber is not opened. Preparation of carious cavity bottom leads to opening of pulp chamber, pulp bleeds and sharp painful. Percussion of the tooth is painless. Palpation of the transitional fold in the projection apex is painless.

Additional methods of examination. Electricity pulp test is reduced to 40-60 μA. X-ray examination does not revealed of any changes in the root apex, usually. But in 30% of cases can be detected expansion of periodontal fissure or focus of the bony tissue at the top of the root.

Differential diagnosis. Chronic pulpitis must be differentiated from caries, from acute pulpitis, pulp necrosis and chronic apical periodontitis.

In dentin caries (deep caries) pain calms down quickly after removing of the irritants. In chronic pulpitis, pain can be continuance (20-30 min).

Acute pulpitis is characterized by spontaneous, irradiated pain, pain in the night. In chronic pulpitis, there are not complaints about the spontaneous and night pain in contrast to acute pulpitis. Chronic pulpitis can occur without any pain. At the same time, chronic pulpitis has common characteristic for all kinds of pulpitis: longstanding pain from temperature irritants, the examination reveals teeth with deep carious cavity.

In pulp necrosis, pain reaction occurs from strong irritants, first of all hot food. In most cases pulp chamber is wide opened, probing of coronal pulp more often is painless. Deep probing of coronal pulp and insertion of the endodontic instruments in the root canal of a tooth cause the pain. Electricity pulp test is reduced to 80 μA.

In chronic apical periodontitis more often, patient doesn't have complaints also. There is painless reaction to temperature stimulus. Probing of the carious cavity bottom is painless. Indicators of Electricity pulp test is 100 mA or more. There are same changes on the radiography.

The objective examination of the tooth with chronic pulpitis determines pain during of probing of the carious cavity bottom, painful reaction to temperature stimulus, no changes on the radiography and positive comparative percussion.

Question 3. Chronic hyperplastic pulpitis (DIC-10, 1997) (Chronic hypertrophic pulpitis Gofung E.M., 1927)

This form of pulpitis often develops from a chronic pulpitis when crown significantly destroyed, and where the carious cavity has one wall of the cervical margin of the tooth. It develops mainly in young patients.

The patient complains on the pain that arises from various kinds of irritants, especially from mechanical irritants, bleeding from the tooth. In some cases, it is possible the bleeding with the full painless. Pain can be occurred while chewing only.

Basic methods of examination. During examination, carious cavity is revealed which is filled by the overgrown pulp tissue. It is denser than granulation tissue, while touching it bleeds easily with mild pain. Reaction to temperature stimulus is painless. Percussion of a tooth and palpation of the transitory fold in the projection of root apex are painless.

When formed polyp pulp cavity is detected the tumor tight light-pink lump. Probing does not lead to bleeding, slightly painful.

Table7. **Diagnosis**

Pain	It is usually absent.
Hyperplastic form	shows a fleshy, reddish pulpal mass which fills most of pulp chamber or cavity. It is less sensitive than normal pulp but bleeds easily when probed.
Radiographic changes show	– Chronic apical periodontitis in longstanding cases. – In young patients, low grade longstanding irritation stimulates periapical bone deposition, i.e. condensing osteitis. Radiograph shows areas of dense bone around apices of involved teeth.
Vitality Tests	– Tooth may respond feebly or not at all to thermal test, unless one uses extreme

	cold – More current than normal is required to elicit response by electric pulp tester.

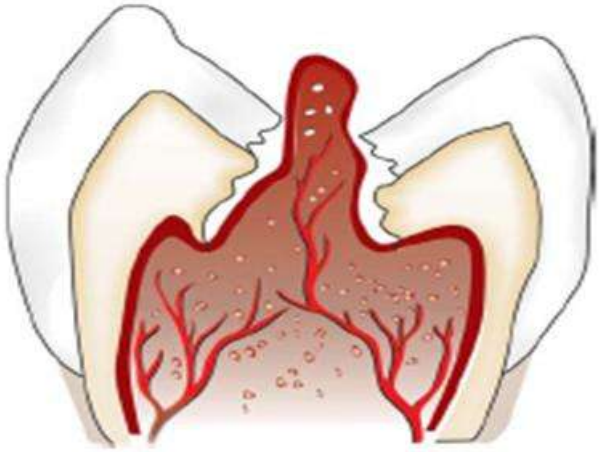


Figure 6. Hyperplastic form of pulpitis

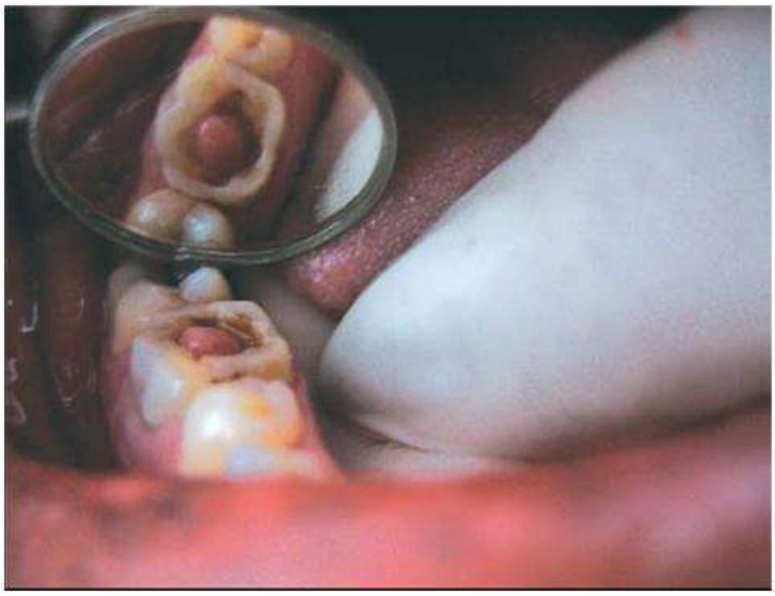


Figure 7. Hyperplastic form of pulpitis showing fleshy reddish pulpal mass filling the pulp chamber

Additional methods of examination. X-ray examination: as a rule, changes in the apex of root of the tooth are absent. Indicators of Electricity pulp test are 20-40 mA.

Differential diagnosis. Chronic hyperplastic pulpitis is differentiated with the proliferation of interdental papilla or the proliferation of granulating tissue from the apical periodontitis, the bifurcation of roots.

The proliferation of papilla is the result of its injury by sharp-edged of decay cavity. The broach is passed on the external edge of the decay cavity pushing back the overgrown papilla to clarify the diagnosis.

If the source of proliferation of granulation tissue was apical periodontitis, the deep probing into the root canal is painless. The perforation of the bottom of the tooth cavity is determined with proliferation of granulation tissue from the furcation, bleed while the probing and it is usually painless. The loss of bone tissue in the furcation of the tooth roots and periapical changes are determined on radiographs.

Question 4. Chronic ulcerative pulpitis (DIC-10, 1997)

Complaints of chronic ulcerative pulpitis are the same as in chronic pulpitis.

Basic methods of examination. During examination a deep carious cavity is defined which is formed by softened dentin. Pulp chamber is opened. In place of the connection of pulp chamber and carious cavity the pulp has ulcerative surface and can be covered by a layer of necrotic plaque. Pulp is bleeding while probing. Probing tooth cavity is painful or slightly painful. Comparative tooth percussion is positive. Palpation of transitional fold in the projection of the tooth root apex painless.

Additional methods of examination are the same as in chronic pulp.

Differential diagnosis. Chronic ulcerative pulpitis must be differentiated from chronic pulpitis by pulp necrosis and chronic apical periodontitis.

The general for chronic and chronic ulcerative pulpitis are both the possibility of asymptomatic disease course and remaining of pain reaction on irritants. However, usually in chronic pulpitis there is no connection between carious cavity and tooth cavity, probing of a carious cavity bottom is painful at one point, pulp chamber is opening while preparing. It leads to appearance sharp painful and bleeding. In chronic ulcerative pulpitis the connection between a pulp chamber and carious cavity are defined while probing. The pulp surface can be covered with a layer of necrotic plaque and has a bad smell of decay. The probing is painless or slightly painful. Bleeding can be observed.

When chronic apical periodontitis probing, including, deep probing is painless there is no reaction to temperature stimulus. There can be changes of mucosal membrane in the area of the abscessed tooth. Indicators EOD is 100 mA and higher. Destructive changes in periapical dental tissues are determined radiographically.

When pulp necrosis, the probing of coronal pulp is painless. Often it is defined the putrid smell from cavity of the tooth. Characteristic complaint is the increased pain from heat. Percussion can be painful.

Question 5. Pulp necrosis (DIC-10, 1997) (Chronic gangrenous pulpitis Gofung E.M, 1927)

Pulp necrosis or pulp cell death is a condition following untreated pulpitis. The pulpal tissue becomes dead and if the condition is not treated, noxious materials will leak from pulp space forming the lesion of endodontic origin. Necrosis may be partial or total, depending on extent of pulp tissue involvement.

Pulp necrosis in most cases is the end result of inflammation and can also occur as a result of traumatic effects that violate the blood supply.

The pulp necrosis is of two types:

1. Coagulation necrosis: In coagulation necrosis protoplasm of all cells becomes fixed and opaque. Cell mass is recognizable histologically, intracellular details lost.
2. Liquefaction necrosis: In liquefaction necrosis the entire cell outline is lost. The liquefied area is surrounded by dense zone of PMNL (dead or drying), chronic inflammatory cells.

Etiology. Necrosis is caused by noxious insult and injuries to pulp by bacteria, trauma, and chemical irritation.

Symptoms

- Discoloration of tooth. First indication of pulp death
- History from patient
- Tooth might be asymptomatic.

Diagnosis

1. Pain: It is absent in complete necrosis.

2. History of patient reveals past trauma or past history of severe pain which may last for some time followed by complete and sudden cessation of pain.

3. Radiographic changes: Radiograph shows a large cavity or restoration or normal appearance unless there is concomitant apical periodontitis or condensing osteitis.

4. Vitality test: Tooth is nonresponding to vitality tests. But multirooted teeth may show mixed response because only one canal may have necrotic tissue.

Sometimes teeth with liquefaction necrosis may show positive response to electric test when electric current is conducted through moisture present in a root canal.

5. Visual examination: Tooth shows color change like dull or opaque appearance due to lack of normal translucency.

6. Histopathology: Necrotic pulp tissue, cellular debris and microorganisms are seen in pulp cavity. If there is concomitant periodontal involvement, there may be presence of slight evidence of inflammation.

Basic methods of examination. The patient complains of aching pain from various types of stimuli, not complacent after the termination of these stimuli. The pain is aggravated by heat, there may be a change of temperature - when entering the street, bad smell from the mouth. Sometimes there are no complaints. The patient tells that had severe pain in the past, which decreased or completely disappeared.

During examination a deep carious cavity with wide opened tooth cavity is defined. Enamel has a gray tint. In the primary stages of a gangrenous lesion (necrosis) the probing of coronal pulp is painful and causes bleeding. This stage of the pathological process corresponds to the "chronic ulcerative pulpitis". Then crown pulp can completely decompose. Tooth has a gray color. Percussion is painful. Palpation of the transitional fold in the projection of root apex is painless.

Pulp necrosis may be as a result of trauma. The tooth looks perfectly healthy. There are no any painful symptoms except the change of color. From history trauma of the tooth.

Additional methods of examination. Action of thermal stimuli causes pain which appears slowly and gradually passes off. There are destructive periodontal changes in the form of expansion of periodontal gap or destructive lesions of bone tissue in the root apex. Electricity pulp test is up to 90 mA.

Differential diagnosis. Compared to chronic ulcerative pulpitis, in case of pulp necrosis probing of crown pulp is painless. Often characteristic putrid smell is defined from the cavity of the tooth. Typical complaint is pain from heat. Percussion can be painful.

In the case of chronic apical periodontitis, there can be changes on the mucous membrane in the area of the projection of tooth root apex. The insertion of endodontic instrument into the root canal is painless. Electricity pulp test of pulp is above 100 μA. Destructive changes in tooth root apex are defined on radiographs.

Figure 8. Tooth decay resulting in pulpal necrosis

Table 8. **Different features of pulpitis**

Features	***Reversible pulpitis***	Acute pulpitis	Chronic pulpitis	Hyperplastic pulpitis	Pulp necrosis
Pain and stimulus	Mid pain lasting for a moment	Constant to severe pain caused by hot or cold stimuli	Mild and intermittent	Pain not present but it bleeds due to presence of rich network of blood vessels in granulomatous tissue into carious cavity	Not present
Stimulus	Heat, cold or sugar	Hot or cold Spontaneous	Spontaneous Dead/injured pulp tissue acts as secondary stimulus		
Pulp test Thermal	Readily responds to cold	Acute pain to hot stimuli	No response	No response	No response
Electric	Normal response	Normal to elevated response	More current is required with electric tester	More current is required response is seen	In cases of liquefaction necrosis, positive
Radiograph	Deep caries, Defective restoration	Deep caries, Defective restoration	1) Chronic apical periodontitis 2) Local condensing osteitis	Same Same	− Large restoration − Sometimes apical periodontitis or condensing osteitis
Treatment	Removal of decay, restoration with pulp protection, occlusal adjustment	Pulpotomy Root canal therapy	RCT Extraction of nonrestorable tooth	Removal of polypoid tissue with curette/ spoon excavator followed by RCT	RCT/extraction

Question 6. Degeneration pulp (ICD-10, 1997).

Pulp degeneration is generally present in older people. It may be the result of persistent mild irritation in the teeth of younger people. Usually pulp degeneration is induced by attrition, abrasion, erosion, bacteria, operative procedures, caries, pulp capping and reversible pulpitis.

It may occur in following forms:

1. Atrophic degeneration and fibrosis

- It is wasting away or decrease in size which occurs slowly as tooth grows old. There is gradual shift in ratio and quality of tissue elements. In this condition number of collagen fibers/unit area increases leading to fibrosis. Number of pulp cells and size of cells decreases so the cells appear as "shrunken solid particles in a sea of dense fibers"
- Fibroblastic processes are lost, cells have round and pyknotic nuclei
- Dentinoblasts decrease in length, appear cuboidol or flattened.

2. Calcifications

In calcific degeneration, part of the pulp tissue is replaced by calcific material. Mainly three types of calcifications are seen in pulp:

- Dystrophic calcification
- Diffuse calcification
- Denticles/pulp stones.

Dystrophic Calcifications. They occur by deposition of calcium salts in dead or degenerated tissue. The local alkalinity of destroyed tissues attracts the salts. They occur in minute areas of young pulp affected by minor circulatory disturbances, in blood clot or around a single degenerated cell. It can also begin in the connective tissue walls of blood vessels and nerves and follow their course.

Diffuse Calcifications. They are generally observed in root canals. The deposits become long, thin and fibrillar on fusing.

Denticles/Pulp Stone. These are usually seen in pulp chamber.

Denticle and other calcareous deposits in the pulp tissue can be referred to degeneration of the pulp. Denticle means hard odontinoidmaterial which is disposed in the pulp. Denticle is considered as substitutive secondary dentin.

They are formations ofdifferent size and shape, from small grains to the size of whole pulp cavity.

By location denticle is distinguished:

1) lying freely, located in pulp and surrounded by it;

2) parietal, allied with dentin wall;

3) interstitial, located in the dentin.

So-called petrification of pulp occurs when pulp enters a period of degeneration (regeneration) and salt deposes in pulp. Usually petrification of pulp discovered by chance as denticlewhile treatment of the extensive caries.

Pulpatrophy refers to degeneration of pulp. Atrophy of pulp is completely painless and is occurred in the elderly. During cutting teeth with pulp atrophy is seen the significant narrowing of the pulp cavity, particularly the canals. The main reason of atrophy is poor diet of pulp tissue, which is observed in most cases in old age (senile atrophy) and due to changes in blood vessels and decreasing of nutritional material.

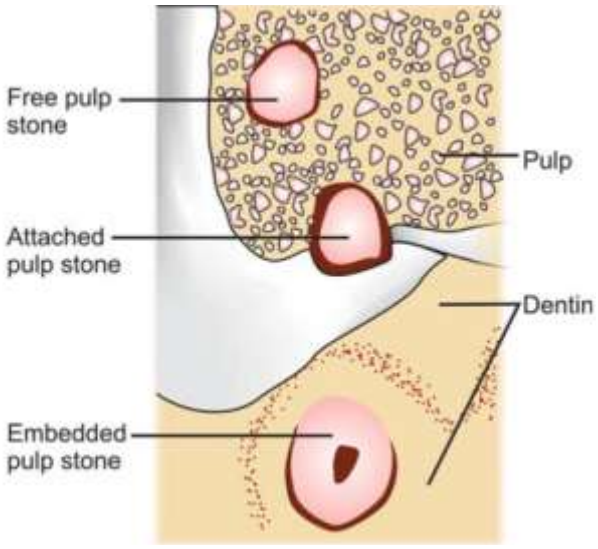


Figure 9. Types of stones

Tests to the topic

1. In chronic gangrenous pulpitis the excitability threshold of pulp is:

a. 1-2 μa.
b. 20-40 μa.
c. 50-90 μa.
d. 100-200 μa.

2. Paroxymal pain from different types of irritants, remaining after their removal, disturb patients with pulpitis:

a. Acute focal.
b. Acute diffuse.
c. Chronic fibrous.
d. Chronic gangrenous.
e. Chronic hypertrophic.

3. Aching dull pain from different types of irritants, mainly from the heat, do not stop, after their removal and from temperature changes of the air occur in pulpitis:

a. Acute focal.
b. Acute diffuse.
c. Chronic fibrous.
d. Chronic gangrenous.
e. Chronic hypertrophic.

4. Chronic pain from different types of irritants, bleeding while eating occur in pulpitis:

a. Acute focal.
b. Acute diffuse.

c. Chronic fibrous.
d. Chronic gangrenous.
e. Chronic hypeplastiic.

5. By location denticle is distinguished:
a. lying freely, located in pulp and surrounded by it;
b. parietal, allied with dentin wall; interstitial, located in the dentin.
c. All answers are correct.

6. In chronic forms of pulpitis, thermal testis:
a. Sharply painful.
b. Painful.
c. Painless.

7. Electroexcitability of pulp in inflammation:
a. Increases.
b. Reduces.
c. Remains unchanged.

8. Chronic fibrous pulpitis is differentiated from:
a. Other forms of pulpitis.
b. Trigeminal neuralgia.
c. Deepcaries, media caries.
d. Papillitis.
e. Acute periodontitis, exacerbation of chronic periodontitis.
f. Neuritis.
g. All answers are correct.

9. Chronic hypeplastic pulpitis is differentiated from:
a. Other forms of pulpitis.
b. Trigeminalneurolgia.
c. Deep caries, media caries.
d. Papillita.
e. Acute periodontitis, exacerbation of chronic periodontitis
f. Neuritis
g. Localized hypertrophic gingivitis

10. The types of pulp necrosis are:
a. Coagulation necrosis.
b. Liquefaction necrosis.
c. All answers are correct.

LESSON 8. TREATMENT METHODS OF PULPITIS. TREATMENT OF PULPITIS WITH LOCAL ANEASTHESIA

Questions to be studied at the classes:

1. Method of full pulp preservation (conservative)
2. Method of partial pulp preservation (vital pulp amputation) or pulpotomy.
3. Surgical methods of treatment of pulpitis: method of vital extirpation or vital pulpectomy.
4. Surgical methods of treatment of pulpitis: method of non-vital pulp extirpation, indications. Complications. Characteristic of medications.

Question 1. Method of full pulp preservation (conservative)

Indications:

1. Reversible pulpitis (hyperemia of the pulp)
2. Traumatic pulpitis (accidentally naked pulp)

Conditions, when we can use this method:

1. Young age (under 30 years old)
2. Prolongation of disease is no longer than 2 days
3. Entrance of the infection was through the carious cavity
4. Carious cavity is localized in limits of anatomic tooth crown
5. Presence of connected with pulp dentin on the bottom of the cavity
6. No changes in periapical tissues

Reversible pulpitis → **Indirect pulp capping**.

This procedure involves the removal of infected dentin except for the deepest, last small amount, which if removed might expose the pulp. Subsequent placement of restorative materials must adequately seal the cavity and provide thermal, mechanical, and chemical protection. If the pulp is healthy, secondary odontoblasts will differentiate and form a layer of reparative dentin for further protection. The decision on whether to re-enter the cavity at a later time (at least 6 months) is based on how much infected dentin was left behind during the indirect pulp capping procedure. This decision must consider the possibility for further injury to the pulp from additional operative procedures.

The goals of this procedure are to prevent pulp exposure and aid pulpal recovery by medication. The portion of the remaining softened dentin is covered with calcium hydroxide liner/base and the excavated area is restored with a temporary material. Calcium hydroxide promotes reparative dentin bridges over any area of frank pulpal exposure. Such repair usually occurs in 6 to 8 weeks and may be evident radiographically in 10 to 12 weeks.

Traumatic pulpits → **Direct pulp capping**.

A direct pulp cap is a technique for treating a pulp exposure with calcium hydroxide to stimulate dentin bridge (reparative dentin) formation. If

the exposure site is the consequence of infected dentin extending into the pulp, termed a carious pulpal exposure, it is likely that infection of the pulp has already occurred and removal of the tooth pulp is indicated. If, however, the pulp exposure occurs in area of normal dentin (usually as a result of operator error or misjudgment), termed a mechanical pulpal exposure, and bacterial contamination from salivary exposure does not occur, the potential success of the direct pulp cap procedure is enhanced. With either type of exposure, a more favorable prognosis for the pulp following direct pulp capping may be expected if:

- ✓ The tooth has been asymptomatic (no spontaneous pain, normal response to thermal testing, and is vital) prior to the operative procedure.
- ✓ The exposure is small, less than 0.5 mm in diameter.
- ✓ The hemorrhage from the exposure site is easily controlled.
- ✓ The exposure occurred in clean, uncontaminated field (such as provided by rubber dam isolation).
- ✓ The exposure was relatively atraumatic and little desiccation of the tooth occurred, with no evidence of aspiration of blood into the dentin (dentin blushing).

Table9. **Examination procedures required to make an endodontic diagnosis**

Medical/dental history	Past/recent treatment, drugs
Main complaint (if any)	How long symptoms duration of pain location onset stimuli relief
Clinical exam	Facial symmetry, sinus tract, soft tissue, periodontal status (probing, mobility), caries, restorations (defective, newly placed?)
Clinical testing: pulp tests periapical tests	 Cold, electric pulp test, heat Percussion, palpation, tooth slooth (biting)
Radiographic analysis	New periapicals (at least 2), bitewing, cone beam-computed tomography
Additional tests	Transillumination, selective anesthesia, test cavity

To summarize, therefore, in reversible pulpitis:

1. The pain is of very short duration and does not linger after the stimulus has been removed.
2. The tooth is not tender to percussion.
3. The pain may be difficult to localize.
4. The tooth may give an exaggerated response to vitality tests.
5. The radiographs present with a normal appearance, and there is no apparent widening of the periodontal ligaments.

In irreversible pulpitis:

1. There is often a history of spontaneous bouts of pain which may last from a few seconds up to several hours.
2. When hot or cold fluids are applied, the pain elicited will be prolonged. In the later stages, heat will be more significant; cold may relieve the pain.
3. Pain may radiate initially, but once the periodontal ligament has become involved, the patient will be able to locate the tooth.
4. The tooth becomes tender to percussion once inflammation has spread to the periodontal ligament.
5. A widened periodontal ligament may be seen on the radiographs in the later stages.

Question 2. Method of partial pulp preservation (vital pulp amputation) or pulpotomy

The main point of the method – operative removing of coronal pulp and medicamental treatment of root pulp.

Indications:

- ✓ Traumatic pulpitis (accidentally wounded pulp)
- ✓ Acute local pulpitis
- ✓ Chronic pilpitis when Electric pulp test is before 40 мкА
- ✓ When direct pulp capping method was not effective
- ✓ The tooth with unformed roots

Conditions:

- ✓ Young age
- ✓ Multi-rooted tooth
- ✓ Carious cavity is localized on tooth crown
- ✓ There is no changes in periapical tissues

Technique stages:

1. Operative field isolation
2. Anesthesia
3. Carious cavity preparation
4. Opening of pulp chamber
5. Pulp amputation by excavator or by wheel-shaped dental drills

6. Hemostasis (diatermocoagulation, haemostatics means: sol. of adrenalinum, hemophobinum, absorbable gelatin sponge, hemocollagene, hemofibrine, 5% aminocaproic acid etc.)
7. Root pulp capping (calcium hydroxide liners: calcipulpe, pulpomixine etc.)
8. Temporary filling
9. Permanent filling (after 3-4 weeks)
10. Electric pulp test in 1, 3, 6, 12 months, X-ray examination

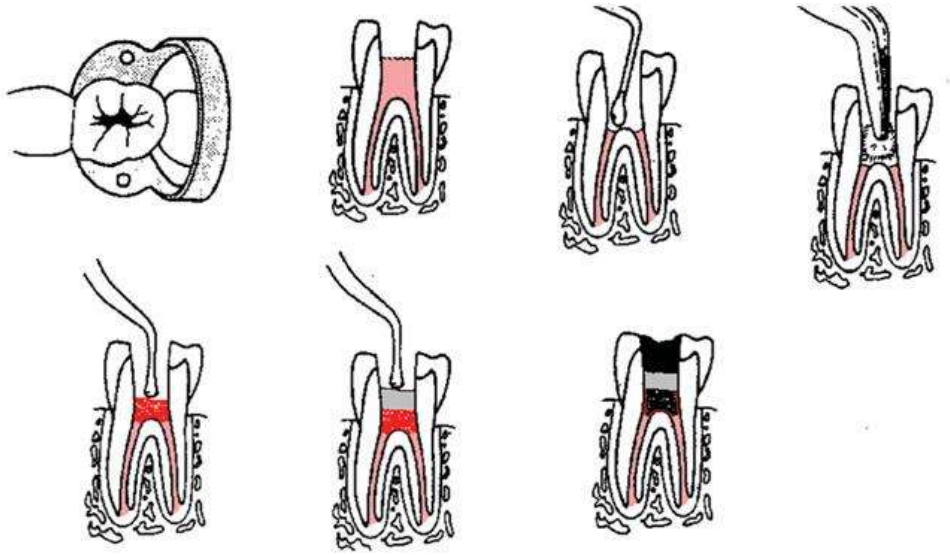


Figure 10. Stages of pulpotomy

Question 3. Surgical methods of treatment of pulpitis:method of vital extirpation or vital pulpectomy.

The method of vital extirpation is based on the delete of all pulp under anaesthesia.

Advantages of method:

1) Treatment is conducted during in one visit;

2) Absence of possible toxic action of arsenic on periodontium;

3) Painlessness of manipulations.

Disadvantages of this method: local and systemic (total)

1) a risk of complications is during conducting of anesthesia (intolerance of anesthetic, action of vasoconstrictive drug, intravascular injection and other);

2) bleeding from a channel, which can arise up during tearing away of vascular-nervous bunch from fabrics of periodontium;

3) absence of reaction is from the side of patient under time of endodontics manipulations;

4) a pains is at that which bite as a result of education haematomas in periapical areas or destroying of stopping material for the apex of root.

Indications for this method. A method is shown at all forms of irreversible pulpitis, especially at ulcerative, hyperplastic pulpitis and necrosis of pulp, when to use arsenic paste it is contra-indicated.

Contraindications for this method

1. Deciduous teeth with resorpted roots.
2. Teeth with unformed roots.
3. Patients with intolerance to anaesthesia
4. Root canals are impassable.

Difficulty with local analgesia is a common problem with an acute inflammation of pulp. In addition to standard techniques, supplementary analgesia can be obtained with the following:

1 Additional infiltration anaesthesia, such as long-buccal, lingual and palatal.

2 Intraligamental (intra-osseous) injection.

3 True intra-osseous injection.

4 Intrapulpal analgesia.

5 Inhalational sedation with local analgesia.

Table 10. **Technique stages**

1st visit:	1. Operative field isolation (rubber dam) 2. Anesthesia 3. Carious cavity preparation 4. Opening of pulp chamber 5. Pulp amputation (excavator, round carbide drill) 6. Widening of root canals orifice (gates-glidden drill, peeso reamer, orifice opener (widener)) 7. Pulp extirpation (barbed (nerve) broash) 8. Hemostasis (hemostatics: sol. of adrenalinum, H_2O_2, hemophobinum, Alustin, absorbent cotton points) 9. Widening of root canals (step-back, crown-down techniques; chemical widening: Canal+, Largal Ultra, Parcan) 10. Cleaning of the root canals with antiseptics (3% sol. of H_2O_2, sol. NaOCl, 2% sol. of Chlorhexidini bigluconatis) 11. Hermetization of root canals with antiseptic past (Dicamphen, Cresophene, Camphocresol, Camphenol, Falicid, Endotine, Grinazole etc.) 12. Temporary filling
2nd visit (after 1-2 days):	1. Removing of the temporary filling 2. Cleaning of root canals with antiseptics 3. Drying of root canals (septopoints(paper), Sikko Tim,

	Hydrol) 4. Filling of root canals (Sealers: Endomethasone, Endobtur, TubliSeal, Wach's Cement; SealApex, Apexit, CRCS (Calcibiotic Root Canal Sealer); Diaket, ThermaSeal, TopSeal, Lee Endo-Fill; Ketac-Endo. Fillers: Gutta-percha points, silver points) 5. Permanent filling of cavity.

One-visit method in treatment of pulpitis

Indications: chronic fibrous pulpitis, chronic proliferative pulpitis, traumatic pulpitis, acute local pulpitis; orthodontic and prosthetic indications.

Conditions: one-root tooth, no periapical inflammation.

Technique stages:

1. Operative field isolation
2. Anesthesia
3. Carious cavity preparation
4. Opening of pulp chamber
5. Pulp amputation
6. Widening of root canals orifice
7. Pulp extirpation
8. Hemostasis
9. Widening of root canals
10. Cleaning of the root canals with antiseptics
11. Drying of root canals
12. Filling of root canals
13. Permanent filling of cavity

Question 4. Surgical methods of treatment of pulpitis: method of non-vital pulp extirpation, indications. Complications. Characteristic of medications.

Inflammation of the pulp can be removed from the tooth cavity after devitalization.

Indications: acute and chronic pulpitis.

Contrindications:

1. Ulcerative pulpitis.
2. Hyperplastic pulpitis.
3. Necrosis of pulp.

For necrotic pulp used arsenic preparations. The death of the cellular elements of pulp, vessels and nerves occurs as a result of violation of tissue respiration. Arsenious anhydride affect the oxidative processes of the connective tissue. It is important to avoid penetration arsenic anhydride in

periapical tissue. Should therefore be strictly follow required dose of arsenic paste and control the duration of its stay in the tooth.

Also for target of pulp devitalization paraformaldehyde paste is used, in which advance pulp devitalization is longer. Paroformaldehyde is a solid polymer of formaldehyde. Paroformaldehyde paste has low toxicity, after its use in the absence of severe periodontal lesions.

After preparation of cavities under anesthesia need to get access to the pulp by perforating a set (in the cavities of class I) or wall (in the cavities of classes II and V) of the cavity of the tooth. Before opening the pulp chamber it is important to produce a change of bur sterile. Movement should be easy, with no pressure on the bur.

Carious cavity is dried by sterile cotton ball. **Arsenic paste** or other devitalizing paste is placed at the bottom of the carious cavity; carious cavity is closed by airtight bandage. The arsenic devitalizing paste is applied on the exposed pulp when single rooted teeth for 24 hours on multi-rooted teeth for 48 hours. longer-time frame residence paste lead to intoxication apical periodontium by arsenous acid, products of pulp decay and the destruction of periodontal tissues.

Figure 11. ARSENIC PASTE - quick paste for pulp devitalization

Formula: Arsenic, lidocaine hydrochloride, thymol, camphor, phenol, eugenol, m.f. pasta.

Indications: painless and rapid devitalization of the pulp.

Directions for use: before usage good mixing of the paste is recommended. Apply arsenic paste to the opened pulp of the tooth: one-rooted tooth for 24 hour, multiple rooted 48 hour. Before applying devitalizing paste overpulpar layer is to be thinned, but not perforated. The paste is well-absorbed both direct contact with the pulpar tissue or through the thinned overpulpar arch. Apply little quantity of the paste on bottom of the tooth cavity, near the mouth. Cover carious cavity of the tooth without

pressure with semiliquid artificial dentin. Open after 24/48 hour and remove the pulp.

Dosage and precautions: the dosage, necessary for devitalization of one tooth pulp corresponds to a small ball of the paste about 1mm in diameter. The paste contains arsenical anhydride, that's why the strong following of precautions during working with this preparation is required.

Contraindications: patients with the history of allergic reaction and intolerance of arsenical anhydride.

Dental Paste Caustinerf arsenical

*Figure 12.*Caustinerf arsenical (*paste for pulp devitalization)*

Composition: ephedrine hydrochloride 1.00g, Lidocaine 30.00g, Arsenic trioxide 30.00g.

Directions for Use: the medical product is applied as a pellet of paste, the size of a pinhead (about 1 mm in diameter), not more than 10mg.

If the patient can not come within the prescribed period, should apply the arsenious paste with delayed action or paroformaldehyde paste.

Non arsenic dental material for devitalization of pulp

Indications:

- ✓ •pulp devitalization with no use of arsenic;
- ✓ •an additional mean for devitalization with arsenic in repeated procedure

1. The preparation, which contains trioxymethylene - strong antiseptic which in high concentrations causes tissue necrosis. Used as part of devitalizing pastes for necrosis of a dental pulp, it has prolonged action. Devitalization occurs within 5 - 7 days. Does not have a toxic effect on periodontal tissues. Lidocaine with its local anesthetic action reduces the risk of a painful reaction.

Composition: Trioxymethylene, Camphor, Lidocaine, P-chlorophenol, Filler

Recommended use. Paste for pulp devitalization applied without pressure on the opened horn of pulp in the form of a ball with a diameter of 1-2 mm. A cavity is closed without pressure by soft temporary dressing. Time of action of the preparation is 5 - 7 days. As a result, pulp become of a fiber structure and very easy to remove. In some cases it is very difficult to apply this technique, because it is not always possible to achieve direct contact with the pulp. In that case, devitalization must be carried out in two stages. Direct contact may be achieved only in a second step after the reduction of viability of the pulp.

2. The preparation, which contains Polyoxymethylene.

Composition: Polyoxymethylene 46 %, Lidocaine Hydrochloride 37 %, Oil of Cloves 12 %, excipient ad 100 %.

The active ingredient is Polyoxymethylene, a coagulant which acts on albumin and confers the required fibrous consistency to the pulp to facilitate its subsequent extirpation.

Table 11. **Technique stages**

1st visit	1. Operative field isolation 2. Partial preparation of carious cavity 3. Anesthesia (intrapulpal methods (Anesthopulpe, Pulperyl, Pulpomixine…)) 4. Opening of pulp chamber 5. Application of devitalizing paste (Caustinerf arsenical – 7 days, Caustinerf rapid – 3days, Caustinerf Fort sans arsenic – 7-10days, Periodontique sans arsenic – 7days, Paraformaldegid – 7-10days; Depulpin…) 6. Temporary filling
2nd visit	1. Removing of temporary filling 2. Radical preparation of carious cavity 3. Opening of pulp chamber 4. Pulp amputation 5. Widening of root canals orifice 6. Pulp extirpation 7. Widening of root canals 8. Cleaning of the root canals with antiseptics 9. Drying of root canals 10. Filling of root canals 11. Permanent filling of cavity.

Tests to the topic

1. What are the treatment methods of reversible pulpitis?

a. Full pulp preservation method.
b. Vital pulpectomy method.
c. Non vital pulpectomy method.
d. All of the above.

2. What are the treatment methods of irreversible pulpitis?

a. Full pulp preservation method.
b. Vital pulpectomy method.
c. Non vital pulpectomy method.

3. Conditions for application of full pulp preservation method are:

a. Young age (under 30 years old).
b. Prolongation of disease is no longer than 2 days.
c. Entrance of the infection was through the carious cavity.
d. Carious cavity is localized in limits of anatomic tooth crown.
e. Presence of connected with pulp dentin on the bottom of the cavity.
f. No changes in periapical tissues.
g. All answers are correct.

4. Indications for use of full pulp preservation method:

a. Reversible pulpitis.
b. Hyperemia of the pulp.
c. Traumatic pulpitis.
d. Acute pulpitis.

5. What are indications for use of vital pulp amputation method?

a. Traumatic pulpitis (accidentally wounded pulp).
b. Acute local pulpitis.
c. Chronic pilpitis when Electric pulp test is before 40 мкА.
d. When direct pulp capping method was not effective.
e. The tooth with unformed roots.
f. All of the above.

6. What are conditions for application of vital pulp amputation method?

a. Young age.
b. Multi-rooted tooth.
c. Carious cavity is localized on tooth crown.
d. There is no changes in periapical tissues.
e. All of the above.

7. What are surgical methods of treatment of pulpitis?

a. Vital pulpectomy method.
b. Non vital pulpectomy method.
c. All of the above.

8. Non arsenic pastes for pulp devitalization contain:

a. Paraformaldehyde.
b. Trioxymethylene.
c. Polyoxymethylene.
d. MTA.
e. Calcium hydroxide.

9. Tools for pulp amputation are:

a. Excavator.
b. Round bor.
c. H-file.

10. Tools to remove the root pulp:

a. Round bor.
b. Excavator.
c. H-file.
d. Nerve broaches.

LESSON 9. THE MECHANISM OF DEVELOPMENT OF APICAL PERIODONTITIS

Questions to be studied at the classes

1. Classification of diseases of periapical tissues.
2. Etiology of apical periodontitis.
3. The pathways of infection at apical periodontitis. Endodontic microbial culture.
4. Pathogenesis of acute apical periodontitis.
5. Pathohystology, pathogenesis of chronic apical periodontitis.

Question 1. Classification of diseases of periapical tissues

Apical periodontitis is inflammation of the periodontium caused by infection of the pulp canal system. Being an inflammatory disease, apical periodontitis can be classified on the basis of symptoms, cause, histopathology and so on. The World Health Organization (WHO) classified apical periodontitis under diseases of periapical tissues into several categories based on clinical signs.

Table12. **WHO (1995) classification of diseases of periapical tissues**

Code number	Category
K04.4	Acute apical periodontitis
K04.5	Chronic apical periodontitis (Apical granuloma)
K04.6	Periapical abscess with sinus (Dentoalveolar abscess with sinus, Periodontal abscess of pulpal origin)
K04.60	Periapical abscess with sinus to maxillary antrum
K04.61	Periapical abscess with sinus to nasal cavity
K04.62	Periapical abscess with sinus to oral cavity
K04.63	Periapical abscess with sinus to skin
K04.7	Periapical abscess without sinus (Dental abscess without sinus, Dentoalveolar abscess without sinus, Periodontal abscess of pulpal origin without sinus)
K04.8	Radicular cyst (Apical periodontal cyst, Periapical cyst)
K04.80	Apical and lateral cyst
K04.81	Residual cyst
K04.82	Inflammatory paradental cyst

This useful classification, however, does not take into account the structural aspects of the diseased tissues. As the structural framework forms the basis of understanding of the disease process, a histopathologic classification is used here. It is based on the distribution of inflammatory

cells within the lesion, the presence or absence of epithelial cells, whether the lesion has been transformed into a cyst, and the relationship of the cyst-cavity to the root canal of the affected tooth.

Acute apical periodontitis is acute inflammation of the periodontium of endodontic origin that is characterized by the presence of a distinct focus of neutrophils within the lesion. It is said to be primary when the inflammation is of short duration and is initiated within a healthy periodontium in response to irritants.

There is secondary inflammation when the acute response occurs in an already existing chronic apical periodontitis lesion.

Chronic apical periodontitis is a long –standing inflammation of the periodontium of endodontic origin that is characterized by the presence of a granulomatous tissue, predominantly infiltrated with lymphocytes, plasma cells, and macrophages. The lesions may be nonepithelialized or epithelialized.

Periapical true cyst is an apical inflammatory cyst with a distinct pathologic cavity that is completely enclosed in an epithelial lining so that no communication to the root canal exists.

Periapical pocket cyst is an apical inflammatory cyst containing a saclike, epithelium-lined cavity that is open to and continuous with the root canal.

Question 2. Etiology of apical periodontitis

There are several etiological factors, which cause inflammation in periodontium. The main factor is **microbial infection**, when inflammation of the apical periodontal tissue due to the invasion of these tissues by pathogenic microorganisms through the apical foramen.

Traumatic periodontitis is reaction of the periodontal tissues to injury caused by trauma of any kind.

Physical trauma to tooth or operative procedures which results in dental follicle desiccation or significant heat transfer causes sufficient damage to pulp and its blood supply. It results in inflammation with immediate response involving the production of endogenous inflammatory mediators which cause increase in vascular permeability, stasis and leukocyte infiltration.

In cases of severe trauma to tooth resulting in immediate interruption of blood supply, pulp becomes necrotic but is not infected.

Persistent periapical tissue compression from traumatic occlusion leads to apical inflammatory response.

Chemical periodontitis is a reaction of the materials that have been introduced into the root canal during root canal procedures ranging from initially acute to chronic after longer exposures.

Question 3. The pathways of infection of apical periodontitis. Endodontic microbial culture

The microbial composition of an infected root canal is determined by the route by which the bacteria gain access to the root canal and the number and quality of ecological factors.

There are several routes through which microorganisms can reach the dental pulp. Openings in the dental hard tissue wall, resulting from caries, clinical procedures, or trauma-induced fractures and cracks are the most frequent portals of pulpal infection. However, microbes have also been isolated from teeth with necrotic pulps and apparently intact crowns. Endodontic infections of such teeth are preceded by pulp necrosis. It has been suggested that bacteria from the gingival sulci or periodontal pockets might reach the root canals of these teeth through severed blood vessels of the periodontium. However, it is very unlikely that microorganisms would survive the immunologic defenses between the marginal gingival and the apical foramen. The teeth may clinically appear intact but reveal microcracks in hard tissues. The latter may provide portals of entry for bacteria. Pulpal infection can also occur through exposed dentinal tubules at the cervical root surface because of graps in the cemental coating. The root canal is a unique environment providing a sanctuary to a biologically select anaerobic milieu, which interacts with microbial factors and the availability of nutrients.

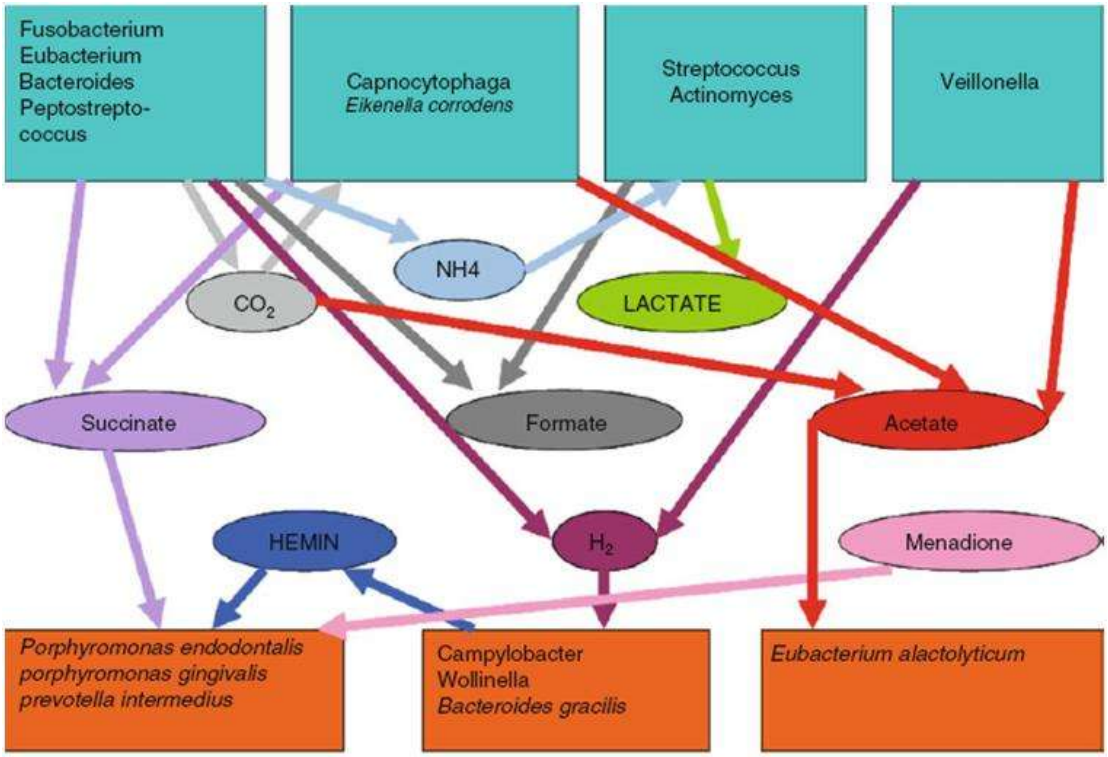


Figure 13. Possible nutritional relationships between bacteria in an infected root canal

Microflora of infected and untreated necrotic pulp

Selective mechanisms allow certain bacteria to survive and multiply more than others. Application of advanced anaerobic techniques helped to establish that the root canal flora of teeth with clinically intact crowns but having necrotic pulp and diseased periapices is dominated by obligate anaerobes usually belonging to the genera *Fusobacterium*, *Porphyromonas*, *Prevotella*, *Eubacterium*, *Peptostreptococcus*. On the other hand, the microbial composition, even in the apical third of the root canal of periapically affected teeth with pulp canals exposed to the oral cavity by caries, is not only different but also less dominated by strict anaerobes. In addition, spirochetes have been found in necrotic root canals using microbiologic methods, dark-field microscopy, and transmission electron microscopy. Spirochetes are motile, invasive pathogens that are associated with certain marginal periodontitis and suggested causative agents of acute necrotizing ulcerative gingivitis. However, their role in apical periodontitis remains to be clarified. Primary intra-radicular infections are characterized by a mixed partnership of 10–30 species per canal. The most prevalent and abundant taxa/groups in primary infections include black- pigmented Gram-negative anaerobic species (*Prevotella and Porphyromonas* species), *Fusobacterium nucleatum*, streptococci, spirochaetes (*Treponema* species), *Dialister* species, *Pseudoramibacteralactolyticus*, *Propionibacterium* species, Parvimonas micra, Tannerella forsythia , Filifactor alocis, *Eubacterium* species and *Olsenella* species.

Certain bacteria only become pathogenic in the presence of other species. It has been suggested that bacteriocins (proteins which have the capacity to inhibit growth of a limited number of species) are responsible for negative associations

Endodontic flora in previously root-filled teeth

The microbiologic nature of root-filled canals is far less understood than that of untreated, infected, necrotic dental pulps. This is probably a consequence of searching for non-microbial causes of purely technical nature for the failure of root canal treatments. The taxonomy of the endodontic flora of root canal-treated teeth depends on the quality of the treatment and obturation of the canals. As such, teeth with inadequate instrumentation, debridement, root canal medication, and poor obturation should be expected to harbor a flora that is similar to that found in untreated canals. On the other hand, only a very restricted number of species has been found in the root canals and periapices of teeth that have undergone proper, conventional endodontic treatment but that, on follow up, reveal persisting, asymptomatic periapical radiolucencies.

The major cause of post-treatment apical periodontitis is persistent or secondary intraradicular infections. Most studies have revealed an overall

higher incidence of Gram-positive bacteria. *Enterococcus faecalis* has been the most frequently detected species in root canal treated teeth. Several as-yet uncultivated bacteria have also been identified in root canal-treated teeth. This suggests that the microbiota associated with posttreatment persistent disease is a mixed bacterial population that is more complex than previous cultural studies suggest. Gram-positive facultative anaerobes commonly associated with samples from root-treated teeth affected by apical periodontitis include *Enterococcus faecalis*, streptococci, lactobacilli, *Actinomyces*, *Peptostreptococcus* spp.

So, the bacteria found in these cases are predominantly gram-positive cocci, rods, and filaments. Using microbiologic techniques, species belonging to the genera *Actinomyces*, *Enterococcus*, *Propionibacterium* are the most frequently isolated and characterized microorganisms from such root canals. The repeated recovery of *Enterococcusfaecalis* deserves particular attention. Although *E.faecalis* is an insignificant organism in infected but untreated root canals, it is extremely resistant to most of the intracanal medicaments used, particularly to the calcium hydroxide-containing dressings. It can also survive in root canals as monoinfection, without any synergistic support from other bacteria. Thus *E.faecalis* is a recalcitrant candidate among the causative agents of failed endodontic treatments.

Earlier microbiologic studies and more recent correlative electron microscopic studies have shown the presence of yeastlike microorganisms in canals of root-filled teeth with unresolving apical periodontitis, so as to implicate fungi as potential therapy-resisting endodontic organisms. *Candidaalbicans* is the most frequently isolated fungus from filled teeth with apical periodontitis.

Table13.**Distinctive features of the microbiota associated with different types of endodontic infections**

	Chronic apical periodontitis	Acute apical abscess	Persistent / secondary Infections
Community	Mixed	Mixed	Mixed / single
No. taxa	10-20	10-20	1-30
Most prevalent groups	Gram negative anaerobes Gram positive anaerobes	Gram negative anaerobes	Gram positive facultative anaerobes
Most frequent taxa	Actinomyces Campylobacter spp dafcsterspp Eikenella corrodes Fusobacterium nucleatum Lactobacilus	Diaister spp Eikenella corrodes Fusobacterium Lactobacillus Peptostreptococcus Porphyromonas spp Prevotella spp	Actinomyces spp Candida abicans (yeast) Enterococcus faecfcs Enteric rods Fusobacterium

	Porphyromonas spp Prevotella spp Propionibacterium Parvimonas micra Peptostreptococcus spp Treponema spp	Streptococcus	nucteatum LactobaciBi Proplonbacterium spp Peptostreptococcus spp Streptococcus spp

Pathogenicity of endodontic flora. Any microbe that infects the root canals has the potential to initiate a periapical inflammation. However, the virulence and pathogenicity of individual species vary considerably and can be affected in the presence of other microbes. Although the individual species in the endodontic flora are usually of low virulence, collectively they are pathogenic due to a combination of factors. These factors include:

1) interactions with other microorganisms in root canal, so as to develop synergistically beneficial partners;
2) the release of endotoxins;
3) the synthesis of enzymes that damage host tissues;
4) the ability to interfere with and evade host defenses.

It has been the subject of numerous terms and classifications. Periapical lesions, apical granuloma and cysts, periapical osteitis, and periradicular lesions are frequently used synonyms. Although periradicular includes inflammation of the furcal and lateral locations, it does not etymologically distinguish the pulpally derived periodontitis from marginally spreading lesions. The limitations of the various terms and the arguments for the preferential retention of apical periodontitis have been discussed recently.

Dentinal Tubule Invasion. The penetration of bacteria into the dentinal tubules. Later studies investigated the depth of penetration of the dentinal tubules, and the reported depths vary from 150 to 2,000 μm, consisting of predominantly Gram-positive rods and cocci. Bacterial penetration of teeth with peri-apical radiolucencies was examined using culturing and histological techniques. Bacteria were found in 62 % of teeth in the layer closest to the cementum layer. Microbiological examination of dentine samples taken at different distances from the canal lumen revealed 90 % of the dentine grindings to show quantitative evidence for penetrationof bacteria towards the CEJ. Gram staining of histological specimens, however, could only detect bacteria from the pulpal–dentinal junction as far as 375 μm.

Question 4. Pathogenesis of acute apical periodontitis

Peri-apical disease is the result of the interactions between bacteria (and their by-products) and the host defences. The non-specifi c and specific branches of the host defences are recruited to defend against the potential invasion of the body by bacteria. The peri-apical lesion represents resorption

of bone away from the source of infection, whereby space is created for the migration of the body's defensive elements to counteract the ongoing infection.

This is usually caused by microorganisms residing in or invading from the apical root canal into the periapical tissue, but it may also be induced by accidental trauma, injury from instrumentation, or irritation from chemicals and endodontic materials, each of which can provoke an intense host response of short duration. It is accompanied by clinical symptoms, such as pain, tooth elevation, and tenderness to pressure on the tooth.

Histopathologically the tissue changes are generally limited to the apical periodontal ligament and the neighboring spongiosa. They are characterized by hyperaemia, vascular congestion, oedema of the periodontal ligament, and extravasation of neutrophils. The latter are attracted to the area by chemotaxis, induced initially by tissue injury, bacterial products, and complement factor C_{5a}. As the integrity of the hard tissues (bone, cementum, dentin) has not yet been disturbed, the periapical changes are radiographically undetecTable If some noninfectious but irritating agents have induced inflammation, the lesion may subside and the structure of the apical periodontium will be restored by healing.

When the infection is involved, the neutrophils not only attack and kill the microorganisms but also release leukotriens and prostaglandins. The former (LTB_4) attracts more neutrophils and macrophages into the area, and the latter activate osteoclasts. In a few days the bone surrounding the periapex can be resorbed and a radiolucent area may be detectable at the periapex. Neutrophils die in great numbers at the inflammatory site and release enzymes from their "suicidal bags", causing destruction of the extracellular matrices and cells.The self-induced destruction of the tissues in the "battle zone" is to prevent the spread of infection to other parts of the body and also to provide space for the deployment of reinforcements arriving in the form of more specialized defense cells as the battle prolongs to a protracted war.

During the later stages of the acute response, macrophages begin to appear the periapex. Activated macrophages produce a variety of mediators, among which the proinflammatory (IL-1, IL-6, TNF-α) and chemotactic (IL-8) cytokines are of particular importance.These cytokines intensify the local vascular response, osteoclastic bone resorption, effector-mediated degradation of the extracellular matrices, and they can place the body on general alert by endocrine action to sharply raise the output of acute-phase proteins and other serum factors by hepatocytes. They also act in concert with IL-6 to up regulate the production of haematopoietic CSF, which rapidly mobilize the neutrophils and the promacrophages from bone marrow. The acute response can be intensified (particularly in later stages) by the

formation of antigen and antibody complexes. The acute early lesion may take several possible courses, such as spontaneous healing, further intensification and spreading into the bone (alveolar abscess), "point" and open to the exterior (fistulation or sinus tract formation), or the lesion may become chronic.

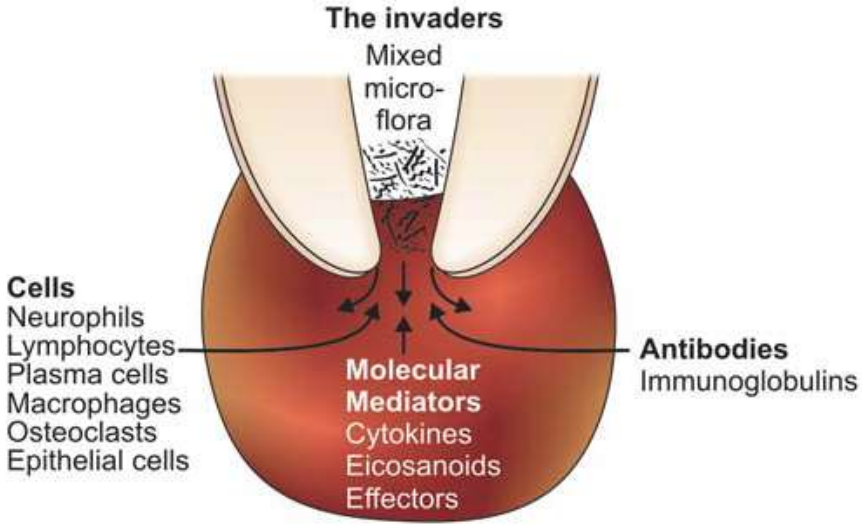


Figure 14. Inflammatory response to periapical lesion

Histopathology

Inflammatory reaction occur in apical periodontal ligament

↓

Dilatation of blood vessels

↓

Initiation of inflammatory response due to presence of polymorphonuclear leukocytes and round cells

↓

Accumulation of serous exudate

↓

Distention of periodontal ligament and extrusion of tooth, slight tenderness

↓

If continued irritation occurs

↓

Loss of alveolar bone.

Acute Apical Abscess

Pathophysiology of apical abscess formation

Increase in pulpal pressure

↓

Collapse in venous circulation

↓

Hypoxia and anoxia of local tissue

↓

Localized destruction of pulp tissue

↓

Formation of pulpal abscess because of breakdown of PMNs, bacterias and lysis of pulp remnants

Histopathology of acute apical abscess

Polymorphonuclear leukocytes infiltrate and initiate inflammatory response

↓

Accumulation of inflammatory exudates in response to active infection

↓

Distention of periodontal ligament

↓

Elongation of tooth

↓

If the process continues, separation of periodontal ligament

↓

Tooth becomes mobile

↓

Bone resorption at apex

↓

Localized lesion of liquefaction necrosis containing polymorphonuclear leukocytes, debris, cell remnants and purulent exudates.

Question 5. Pathohystology, pathogenesis of chronic apical periodontitis

FISH described the reaction of the periradicular tissues to bacterial products, noxious products of tissue necrosis, and antigenic agents from the root canal. He established an experimental foci of infection in the guinea pigs by drilling openings in the jaw bone and packing it with wool fibers saturated with a broth culture of microorganisms. FISH in 1939 theorised that the zones of infection are not an infection by themselves but the reaction of the body to infection. Thus he concluded that the removal of this nidus of infection will result in resolution of infection. Four well defined zones of reaction were found during the experiment:

a. Zone of infection or necrosis (PMNLs)

b. Zone of contamination (Round cell infiltrate – lymphocytes)

c. Zone of irritation (Histiocytes and osteoclasts)

d. Zone of stimulation (Fibroblasts, capillary buds and Osteoblasts).

Zone of Infection. In FISH study, infection was confined to the center of the lesion. This zone is characterized by polymorphonuclear leukocytes and microorganisms along with the necrotic cells and detructive components released from phagocytes.

Zone of Contamination. Around the central zone, FISH observed the area of cellular destruction. This zone was not invaded by bacteria, but the destruction was from toxins discharged from the microorganisms in the central zone. This zone is characterized by round cell infiltration, osteocyte necrosis and empty lacunae. Lymphocytes were prevalent everywhere.

Zone of Irritation. FISH observed evidence of irritation further away from the central lesion as the toxins became more diluted. This is characterized by macrophages, histocytes and osteoclasts. The degradation of collagen framework by phagocytic cells and macrophages was observed while osteoclasts attack the bone tissue. The histologic Figure is much like preparatory to repair.

Zone of Stimulation. FISH noted that, at the periphery, the toxin was mild enough to act as stimulant. This zone is characterized by fibroblasts and osteoblasts. In response to this stimulatory irritant, fibroblasts result in secretion of collagen fibers, which acted both as wall of defense around the zone of irritation and as a scaffolding on which the osteoblasts synthesize new bone. So the knowledge gained in FISH study can be applied for better understanding of reaction of periradicular tissues to a nonvital tooth. The root canal is the main source of infection. The microorganisms present in root canal are rarely motile. Though they do not move from the root canal to the periapical tissues; but they can proliferate sufficiently to grow out of the root canal. The metabolic byproducts of these microorganisms or the toxic products of tissue necrosis may also get diffused to the periradicular tissues. As the microorganisms enter in the periradicular area, they are destroyed by the polymorphnonuclear leukocytes. But if microorganisms are highly virulent, they overpower the defensive mechanism and result in development of periradicular lesion.

The toxic products of the microorganisms and the necrotic pulp in the root canal are irritating and destructive to the periradicular tissues. These irritants along with proteolytic enzymes (released by the dead polymorphonuclear leukocytes) result in the formation of pus. This results in development of chronic abscess.

At the periphery of the destroyed area of osseous tissue, toxic bacterial products get diluted sufficiently to act as stimulant. This results in formation of a granuloma. After this fibroblasts come in the play and build fibrous tissue and osteoblasts restrict the area by formation of sclerotic bone. Along with these if epithelial rests of Malassez are also stimulated, it results in formation of a cyst.

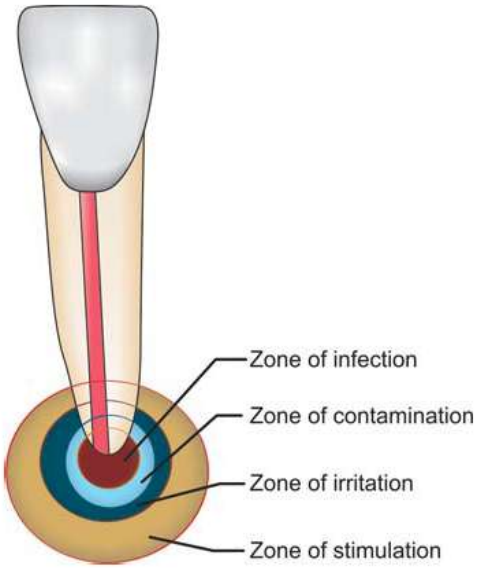


Figure 15. FISH zones

Periapical Granuloma

Periapical granuloma is one of the most common sequelae of pulpitis. It is usually described as a mass of chronically inflamed granulation tissue found at the apex of nonvital tooth.

Etiology of Periapical Granuloma. Periapical granuloma is a cell mediated response to pulpal bacterial products. Bacterial and toxins cause mild irritation of periapical tissues. This leads to cellular proliferation and thus granuloma formation.

Histopathologic Features

- It consists of inflamed granulation tissue that is surrounded by a fibrous connective tissue wall
- The granulation consists of dense lymphocytic infiltrate which further contains neutrophils, plasma cells, histiocytes and eosinophils

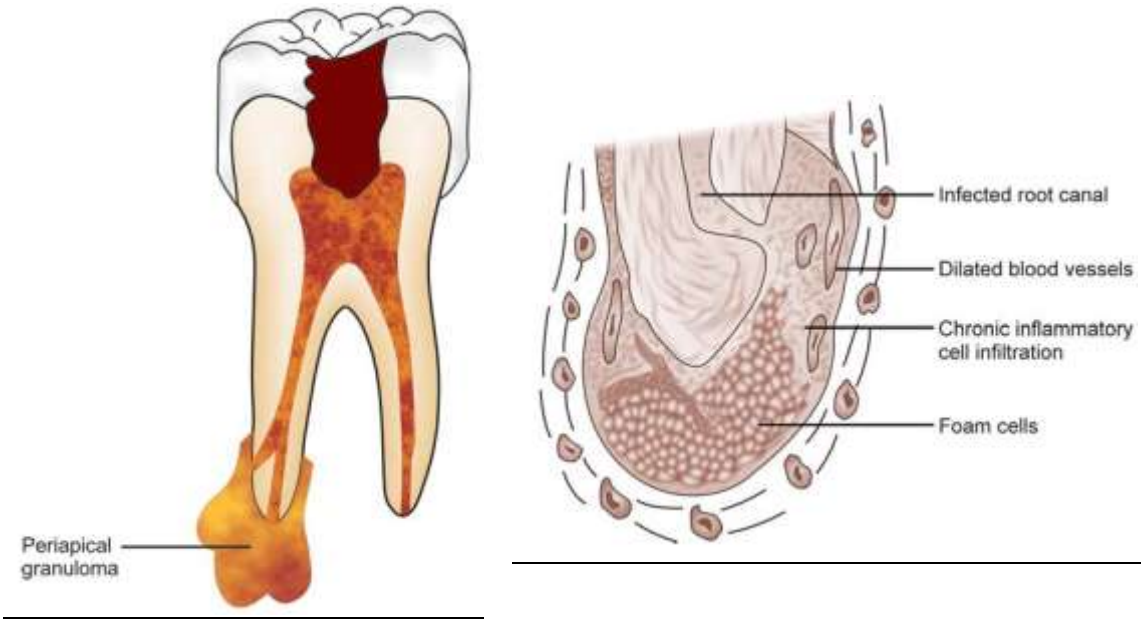


Figure 16. Histopathology of periapical granuloma

Pathogenesis. Periapical granulomas are initiated and maintained by the degradation products of necrotic pulp tissue. Stimulation of the resident epithelial rests of Malassez occurs in response to the products of inflammation. Cyst formation occurs as a result of epithelial proliferation, which helps to separate the inflammatory stimulus from the surrounding bone. When proliferation occurs within the body of the granuloma, it plugs the apical foramen which limits the egress of bacteria. Sometimes, epithelial plugs protrude out from the apical foramen resulting in a pouch connected to the root and continuous with the root canal. Breakdown of cellular debris within the cyst lumen raises the protein concentration, producing an increase in osmotic pressure. The result is fluid transport across the epithelial lining into the lumen from the connective tissue side. Fluid ingress assists in outward growth of the cyst. With osteoclastic bone resorption, the cyst expands. Other boneresorbing factors, such as prostaglandins, interleukins, and proteinases, from inflammatory cells and cells in the peripheral portion of the lesion permit additional cyst enlargement.

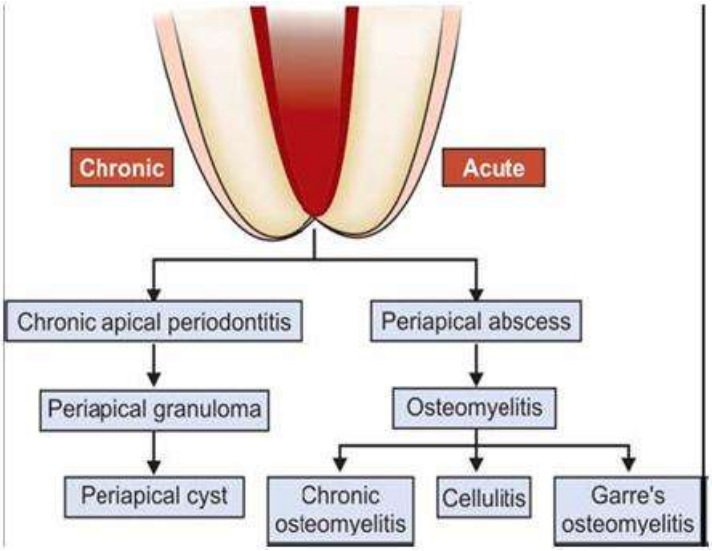


Figure 17. Sequel of pulpal inflammation

Tests to the topic

1. Pathophysiology of apical abscess formation is

a. Increase in pulpal pressure.
b. Collapse in venous circulation.
c. Hypoxia and anoxia of local tissue.
d. Localized destruction of pulp tissue.
e. Formation of pulpal abscess because of breakdown of PMNs, bacterias and lysis of pulp remnants.
f. All of the above.

2. Histopathology of acute apical abscess is

a. Polymorphonuclear leukocytes infiltrate and initiate inflammatory response.
b. Accumulation of inflammatory exudates in response to active infection.
c. Distention of periodontal ligament.
d. Elongation of tooth.
e. If the process continues, separation of periodontal ligament.
f. Tooth becomes mobile.
g. Bone resorption at apex.
h. Localized lesion of liquefaction necrosis containing polymorphonuclear leukocytes, debris, cell remnants and purulent exudates.
i. All of the above.

3. The pathogenicity of the endodontic flora consists of the following factors:

a. Interactions with other microorganisms in root canal, so as to develop synergistically beneficial partners.
b. The release of endotoxins.
c. The synthesis of enzymes that damage host tissues.
d. The ability to interfere with and evade host defenses.
e. All of the above.

4. Histopathologic features of periapical granuloma include

a. It consists of inflamed granulation tissue that is surrounded by a fibrous connective tissue wall.
b. The granulation consists of dense lymphocytic infiltrate which further contains neutrophils, plasma cells, histiocytes and eosinophils.
c. All of the above.

5. Indicate code number according to ICD-10 of acute apical periodontitis

a. K04.4.
b. K02.2.
c. K05.1.
d. K13.3.
e. K14.1.

6. Indicate code number according to ICD-10 of chronic apical periodontitis (Apical granuloma)

a. K04.5.
b. K02.2.
c. K05.1.
d. K13.3.
e. K14.1.

7. Indicate code number according to ICD-10 of periapical abscess with sinus to oral cavity

a. K04.62.
b. K02.2.
c. K05.1.
d. K13.3.
e. K14.1.

8. Clinical tests for determining acute apical periodontitis include

a. Probing.

b. Percussion (horizontal and vertical).
c. Palpation.
d. Determination of mobility.
e. Mechanical test (biting on a solid object).
f. Location of sinus tract.
g. Temperature test.
h. All of the above.

9. Acute serous periodontitis in the Lukomsky classification corresponds to what diagnosis according to ICD-10?

a. Acute apical periodontitis.
b. Chronic apical periodontitis.
c. Periapical abscess with sinus.

10. Chronic granulomatous periodontitis in the Lukomsky classification corresponds to what diagnosis according to ICD-10?

a. Acute apical periodontitis.
b. Chronic apical periodontitis.
c. Periapical abscess with sinus.

LESSON 10. CLINICAL APPEARANCE ACUTE PERIODONTITIS. DIAGNOSTICS. PRINCIPLES OF TREATMENT OF ACUTE PERIODONTITIS

Questions to be studied at the classes

1. Clinical features of acute apical periodontitis.
2. Diagnostic methods of acute apical periodontitis.
3. Differential diagnosis of acute apical periodontitis.
4. Principles of treatment of acute apical periodontitis.
5. Management of an acute apical abscess and acute apical periodontitis.
6. Classification of Intracanal medicaments.

Question 1. Clinical features of acute apical periodontitis

Acute apical periodontitis occurs when pulpal disease extends into the surrounding periradicular tissues causing inflammation. The patient will generally complain of discomfort when biting, chewing, and eating or when the teeth come into contact. Sensitivity to percussion is a telltale diagnostic sign synonymous with acute apical periodontitis. Palpation testing may or may not elicit a sensitive response. Radiographic findings may vary from no obvious observable change to widening of the periodontal ligament space at the apex of the tooth. Occlusal reduction may aid in the reduction of post-instrumentation pain in patients whose teeth exhibit preoperative pain, pulp vitality, percussion sensitivity and/or the absence of a periradicular radiolucency.

Acute, localized, and permanent pain is typical for the acute process in the periapical tissues. At first the pain is not so acute but according to the changes in quality and quantity of the exudation, made intensive; throbbing pain occurs.

Acute periodontitis lasts for 2-3 days up to 2 weeks.

The process goes through two stages:

Stage 1: intoxication of periapical tissues (the beginning of inflammation). Continuous pain and sensitiveness during mastication. Percussion of the tooth is painful. There are no changes in the gums near the affected tooth. Regional lymphatic glands can be slightly enlarged and somewhat painful.

Pathological anatomy: according to the influence of microbial, physical, and other factors cell metabolism in the periapical tissues is changed what leads to the accumulation of altered lactic acid and acidosis, continued with oedema of connective tissue and increase of blood vessels permeability and polymorphonuclear migration.

Stage 2: is the stage of (pronounced) marked exudation and continuous pain with growing intensity. Mastication and even touching to the tooth are

painful. Percussion of the affected tooth is sharply painful mostly in vertical but lately in all directions. Exudation in the apical tissues provokes the filling of tooth growing and its pathological mobility. Gums at the projection of periapical process are oedematous and inflamed. Sometimes the percussion becomes less painful but it leads to the oedema of the vestibule fold. Regional lymphatic glands are increased and painful. EPT>100

The most common features of acute apical periodontitis associated with this diagnosis is pain upon biting, eating, teeth coming into contact, and percussion testing.

Table 14. **The main features ofacute apical periodontitis**

Main complaint	Discomfort when biting or chewing
History	?Recentrestoration
Radiographicfindings	Normal or windened PDL
Electricpulp test	Response / no response
Thermal testing	Variable
Percussion Palpation Mobility	Moderate to severe pain with or without mobility
Treatment	Endodontic treatment
Differential diagnosis	Oclusal trauma

Acute periapical abscess is an acute inflammation of periapical tissue characterized by localized accumulation of pus at the apex of a tooth. It is a painful condition that results from an advanced necrotic pulp. Patients usually relate previous painful episode from irreversible pulpitis or necrotic pulp. Swelling, tooth mobility and fever are seen in advanced cases.

Table 15. **The main features ofacute apical abscess**

Main complaint	Pain with or without swelling
History	Recent deep restoration
Radiographicfindings	Normal or windened PDL
Electricpulp test	No response
Thermal testing	No response
Percussion Palpation Mobility	Exquisitely painful and tenderness in overlying mucosa
Treatment	Incision and drainage Root canal treatment Antibiotics if systemic involvement
Differential diagnosis	Necrotic or pulpless tooth

Question 2. Diagnostic methods of acute apical periodontitis.

Acute Apical Abscess Patients will present with a very painful tooth and pulp testing will indicate a necrotic pulp. Swelling is generally present, and it may be localized to the mucogingival area or it may involve fascial planes and spaces. The tooth is very sensitive to percussion and palpation and may exhibit varying degrees of mobility. Often the tooth may be elevated in the alveolar socket because of pressure from the inflamed tissues around the root. Some cases may not show any evidence of anatomic changes on the radiograph, whereas other cases may show changes that range from a widened PDL space to a frank radiolucent lesion. The patient may or may not exhibit systemic manifestations to include the presence of a fever and/or lymphadenopathy.

Table 16. **Features of acute apical abscess**

Tooth is nonvital	
Pain	– Rapid onset – Readily localized as tooth becomes increasingly tender to percussion – Slight tenderness to intense throbbing pain – Marked pain to biting
Swelling	– Palpable, fluctuant – Localized sense of fullness
Mobility	May or may not be present
Tooth may be in hyperocclusion	
Radiographic changes	No change to large periapical radiolucency

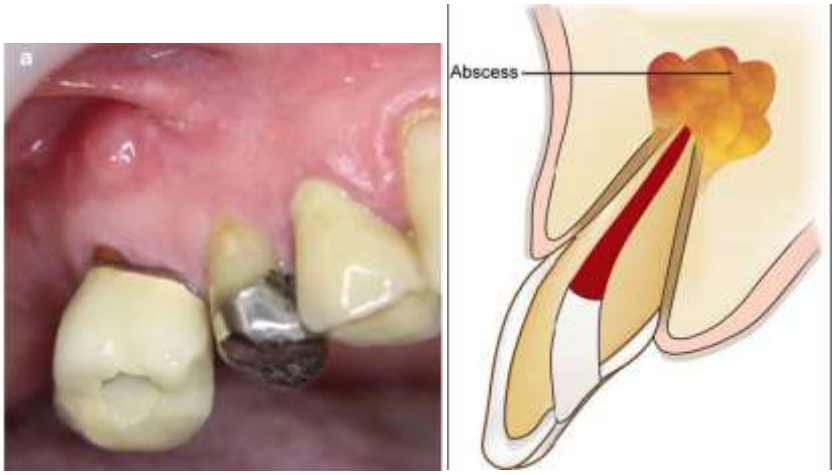


Figure 18. Clinical photographs showing endodontics cases diagnosed as acute apical abscess. Swelling localised to mucogingival area adjacent to tooth 16

Symptoms. In early stage, there is tenderness of tooth which is relieved by continued slight pressure on extruded tooth to push it back into alveolus. Later on throbbing pain develops with diffuse swelling of overlying tissue. Tooth becomes more painful, elongated and mobile as infection increases in latter stages. Patient may have systemic symptoms like fever, increased WBC count. Location of swelling is determined by relation of apex of involved tooth to adjacent muscle attachment.

Diagnosis

1. Clinical examination
2. Initially locating the offending tooth is difficult due to the diffuse pain. Location of the offending tooth becomes easier when tooth gets slightly extruded from the socket.
3. Pulp vitality tests give negative response
4. Tenderness on percussion and palpation.
5. Tooth may be slightly mobile and extruded from its socket.
6. Radiography helpful in determining the affected tooth as it shows a cavity or evidence of bone destruction at root apex.

Question 3. Differential diagnosis of acute apical periodontitis

1. Acute pulpitis.

2. Pulpitis, complicated with apical periodontitis:

- spontaneous throbbing pain with irradiation,
- pain increased after all types of irritants, during mastication and at the nighttime. Light periods is very short or absent at all.
- After perforation of pulp cavity, pulp tissue is painful and bleeds during probing.

3. Acute periostitis:

- Acute pain with irradiation
- Oedema of facial soft tissues
- Palpation is very painful
- Percussion of caused tooth and neighbouring teeth are painful
- Regional lymphatic glands are increased and painful
- Rtg – no changes in the bone tissue
- Asymmetry of the face

4. Acute osteomyelitis:

- Acute boring, darting pain in the jaw
- Sickness, headache, $\uparrow t^0$=38-40^{0}C, fever, sleeplessness, tachycardia, tachypnea
- Asymmetry of the face
- Coated tongue, oedema and inflammation of the gums; fetor ex ore
- Very painful percussion of all teeth on the half of jaw and their mobility

5. Maxillary sinusitis:

- Headache, rhinorrhea, pain in maxillary sinus area, rough breathing; Rtg changes of maxillary sinus

Table 17. **Differential diagnosis of apical periodontitis**

Sign	Acute serous apical periodontitis	Acute purulent apical periodontitis	Exacerbation of chronic apical periodontitis
Anamnesis	Duration of the disease - 24 hours	Duration of the disease - few days	Continuous dull pain or acute self-arising pain in the past; duration – few days.
Kind of pain	Pain (or sensitivity) only during mastication.	Continuous dull (gnawing) and some times throbbing pain, that increased after touching to the tooth. Irradiation of the pain some times occurs. Filling of "tooth growing".	Continuous dull pain.
Mobility of caused tooth	-	+	+
Changes of gum's mucosa	-	Inflammation of the gum's mucosa; pain during palpation.	Edema and inflammation of mucosa and, some times, skin. Pain during palpation. Presence of gingival fistula.
Common condition	Normal	Sickness, headache, $\uparrow t^0$=38-40^{0}C, leucocytosis.	Sickness, headache, $\uparrow t^0$=38-40^{0}C, leucocytosis.

PERIODONTAL PAIN

1. Acute Apical Periodontitis

Diagnosis

1. Check for decay, fracture lines, swelling, hyperocclusion or sinus tracts.
2. Patient has moderate to severe pain on percussion.
3. Mobility may or may not be present.
4. Pulp tests are essential and their results must be correlated with other diagnostic information in order to determine if inflammation is of pulpal origin or from occlusal trauma.
5. Radiographs may show no change or widening of periodontal ligament space in some cases.

2. Acute Periapical Abscess

Diagnosis

1. Spontaneous dull, throbbing or persistent pain is present.
2. Tooth is extremely sensitive to percussion.
3. Mobility may be present.
4. On palpation, tooth may be sensitive.
5. Vestibular or facial swelling in seen in these patients.
6. Pulp tests show negative results.

Question 4. Principles of treatment of acute apical periodontitis.

The main principle of treatment of acute apical periodontitis – to create a good exudate evacuation.

Ways of exudates evacuation:

1. Through the root canal
2. Through the dentogingival junction
3. Through the incision
4. Through the alveole

Acute periodontitis. In the stage of acute inflammation and exudation the tooth is left open for 2-5 days (it is important the exudates to go out from the canal). Only in the first stage of acute inflammation, when there is little exudation tooth can be temporary closed, leaving in the canal antimicrobial and anti-inflammatory medications.

Trepanation (opening of the tooth) or removing the filling is painful and must be done under local anesthesia, and with the lowest pressure from the handpiece.

It is very important not only to widen the canal but also to open apical foramen. Only in this case the exudates will be let out.

When the signs of general intoxication are present (headache, rising of body temperature, weakness, changes in general blood formula), antibiotics, antimicrobial medications (active to anaerobic microorganisms) should be administrated.

When the periapical inflammation is complicated by periostitis, periosteotomy must be done (horizontal incision 2-3 cm long) to achieve exudates and let the pus go out.

In next visit, when the signs of acute inflammation decrease, the canal is mechanically treated and washed by antiseptic solutions (chloramin, furacilin, chlorhexydin, proteolytic enzymes or antibiotics) and closed by temporary filling. Root canal is usually filled in the third visit.

Management

1. Anesthesia of the involved tooth
2. Preparation of the access cavity

3. Total extirpation of pulp in pulp chamber
4. Determination of working length
5. Total extirpation of the pulp
6. Cleaning and shaping of the root canal
7. Thorough irrigation
8. Placement of sedative dressing followed by closed dressing
9. Relieve occlusion if indicated
10. Prescribe analgesics to reduce the pain.

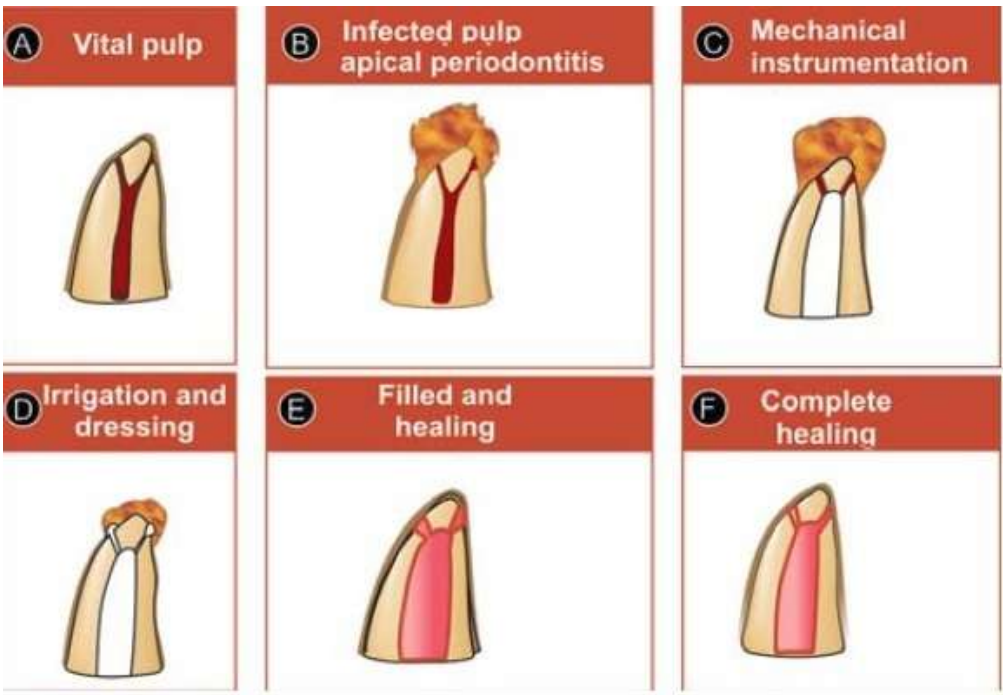


Figure 19. Management of acute apical periodontitis

Acute Apical Abscess. Prompt management will be required to prevent potentially life-threatening spread of infection and urgent referral if local measures do not provide adequate relief.

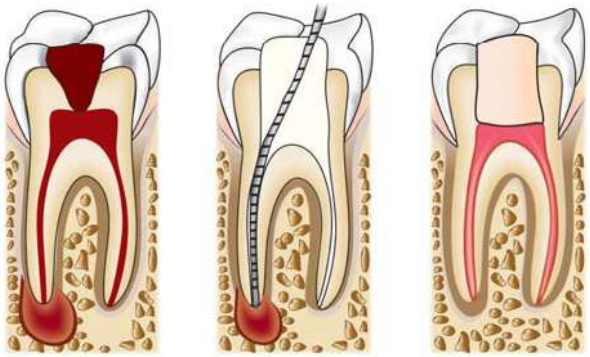


Figure 20. Opening of root canal system for drainage

Question 5. Management of an Acute Apical Abscess

1. Biphasic treatment:
    a. Pulp debridement.
    b. Incision and drainage.
2. Do not leave tooth open between appointments.
3. In case of localized infections, antibiotics provide no additional benefit.
4. In case of systemic features, antibiotics should be given.
5. Relieve the tooth out of occlusion in cases of hyperocclusion.
6. To control postoperative pain, NSAIDs should be prescribed.
7. Speed of recovery will rely on canal debridement.

Principles

- ✓ Drainage of the abscess should be initiated as early as possible. This may include:
    a. Non-surgical endodontic treatment (Root canal therapy).
    b. Incision and drainage.
    c. Extraction.
- ✓ Considerations regarding the treatment should be dependent on certain factors:
    a. Prognosis of the tooth.
    b. Patient preference.
    c. Strategic value of the tooth.
    d. Economic status of the patient.

The main factor which is needed for successful treatment of pulp and periradicular inflammation is complete removal of the source of infection such as microorganisms and their byproducts.

Question 6. Classification of Intracanal medicaments.

Following measures should be taken to completely rid of these irritants:

1. Thorough cleaning and shaping of the root canal system.

Root canal system is thoroughly cleaned and shaped to remove the bacteria and substrates which can support microorganisms. Thorough cleaning and shaping followed by three dimensional obturation of the root canals have shown to produce complete healing of periradicular tissue. Complete debridement of canal should be done with adjunctive use of **irrigants like sodium hypochlorite** which efficiently removes bacteria as well as their substrate from irregularities of canal system. **NaOCl** is considered an excellent antimicrobial agent with tissue dissolving properties. It can be used alone or in combination with other irrigants like chlorhexidine, EDTA, hydrogen peroxide.

Functions of irrigants

1. Remove dentinal shavings by physical flushing.
2. Increase the efficiency of instruments.

3. Dissolve necrotic tissue.
4. Remove debris from lateral and accessory canals.
5. Germicidal as well as antibacterial properties.
6. Bleaching action.
7. Irrigants with lubricating agent further increase the efficiency.
8. Opening of dentinal tubules by removal of smear layer.

Root canal disinfectants

Halogens

Chlorine. Irrigating solution: Sodium hypochlorite 0.5 to 5.25 % in aqueous solution.

Iodine. Irrigating solution: 2 % I2 in 5 % KI aqueous solution; iodophors.

Surface disinfection: 5 % I2 in tincture of alcohol.

Chlorhexidine. Chlorhexidine gluconate Irrigating solution: 0.12-2.0 % aqueous solution.

Calcium hydroxide. Dressing: aqueous or viscous formulation with varying amounts of salts added. Antibacterials like iodine, chlorphenols, chlorhexidine may also be added.

Aldehydes

Formocresol. Dressing: 19 % formaldehyde, 35 % cresol, 46 %water and glycerine.

Figure21. Formocresol

Phenols

Camphorated phenol

Figure22. Camphorated phenol

Paramonochlorphenol(PMCP)

Composition: 2 parts of para-chlorophenol + 3 parts gum camphor = Camphorated monochlorophenol (CMCP)

Camphor is added to parachlorophenol (PCP) because it

1. Has diluent action
2. Prolongs the antimicrobial effect
3. Reduces the irritating effect of PCP
4. Serves as a vehicle for the solution

Irrigating solution: 2 % aqueous solution .

Dressing: CMCP; 65 % camphor, 35 % PMCP.

Eugenol. Formation of electrochemically activated solution.

2. A tooth with serous or purulent or hemorrhagic exudate should be allowed to drain with rubber dam in place for a time under supervision. An abscess which is a potent irritant, has an elevated osmotic pressure. This attracts more tissue fluid and thus more edema and pain. Drainage by canal or by soft tissues decrease discomfort caused by inflammatory mediators.

Table 18. **Technique stages when purulent inflammation periapical tissues**

I-st visit	1. Anesthesia 2. Operative field isolation 3. Carious cavity preparation 4. Evacuation of necrotic tissues from the root canal 5. Opening of the root canal apex

	6. Cleaning of the root canal with antiseptics 7. Leaving the tooth open
II-nd visit	1. Widening and cleaning of root canal 2. Drying of root canals 3. Temporary filling root canals
III-rd visit	1. Removing of the temporary filling 2. Cleaning of root canals with antiseptics 3. Drying of root canals 4. Filling of root canals 5. Tooth restoration

3. Intracanal medicaments play an important role in combating the microorganisms.

Table 19. **Effects of Calcium Hydroxide**

Physical	✓ Acts as a physical barrier for ingress of bacteria. ✓ Destroys the remaining bacteria by limiting space for multiplication and holding substrate for growth.
Chemical	✓ It shows antiseptic action probably because of its high pH and its leaching action on necrotic pulp tissues. It also increases the pH of circumpulpal dentin when placed into the root canal. ✓ Suppresses enzymatic activity and disrupts cell membrane ✓ Inhibits DNA replication by splitting it. ✓ It hydrolyses the lipid part of bacterial lipopolysaccharide (LPS) and thus inactivates the activity of LPS. This is a desirable effect because dead cell wall material remains after the killing of bacteria which may cause infection.

Calcium hydroxide is available in
a. Paste form: Single paste or in combination with iodoform.

Figure23. Metapex based on calcium hydroxide

b. Powder form: Powder form is mixed with saline and anesthetic solution. For placement in root canals it is coated with the help of paper points, spreaders or lentulo spirals.

Indications of Calcium Hydroxide

1. In weeping canals
2. In treatment of abscess
3. In resorption cases
4. For apexification
5. During pulpotomy
6. For non surgical treatment of periapical lesion
7. In cases of direct and indirect pulp capping
8. As sealer for obturation
9. To decrease postoperative pain after over instrumentation, it is used in combination with Ledermix (1:1)

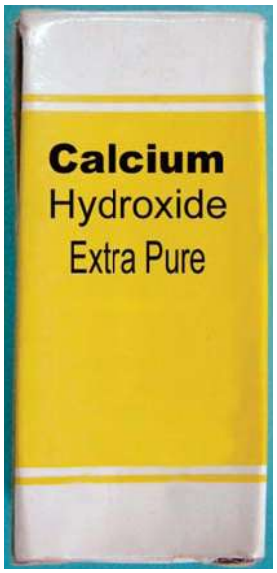


Figure 24.Calcium Hydroxide

Use of calcium hydroxide in canals with necrotic pulps after instrumentation have shown to provide the beneficial results. Intracranial use of calcium hydroxide have shown to increase the efficiency of sodium hypochlorite and also the effectiveness of antimicrobial agent. Calcium hydroxide powder is mixed with water or glycerin to form a thick paste which is placed in pulp chamber with amalgam carrier or a syringe. This paste is covered with a sterile cotton pellet and access is sealed with temporary restoration. An intra-canal dressing of calcium hydroxide is placed for a 2-week period prior to permanent obturation.

Acute toxic periodontitis (produced by the prolonged influence of As-paste or its overdose). The successful treatment needs quick removing of the pulp remnants. Root canals should be washed by antiseptics (1-2% chloramin, 3% hydrogen peroxide, furacilinum 1:5). After this procedure

medications As-antidotes are left in the root canal (5% solution of unitiol, 1% solution of jodinolum). Electrophoresis with KJ can be recommended when inflammation is not acute. Temporary filling leaving one of the abovementioned antidotes in the canals can close tooth. In next visit (after 1-2 days), in the case the signs of inflammation are absent root can be filled. In the case of acute inflammation (painful percussion, exudation from the canal) the tooth is left open till next visit.

Tests to the topic

1. Features of acute apical abscess are

a. Tooth is nonvital.
b. Pain.
c. Swelling.
d. Mobility.
e. Tooth may be in hyperocclusion.
f. Radiographic changes.
g. All of the above.

2. Diagnosis of acute apical abscess is

a. Clinical examination.
b. Initially locating the offending tooth is difficult due to the diffuse pain. Location of the offending tooth becomes easier when tooth gets slightly extruded from the socket.
c. Pulp vitality tests give negative response.
d. Tenderness on percussion and palpation.
e. Tooth may be slightly mobile and extruded from its socket.
f. Radiography helpful in determining the affected tooth as it shows a cavity or evidence of bone destruction at root apex.
g. All of the above.

3. Differential diagnosis of acute apical periodontitis is

a. Acute pulpitis.
b. Pulpitis, complicated with apical periodontitis.
c. Acute periostitis.
d. Acute osteomyelitis.
e. Maxillary sinusitis.
f. All of the above.

4. Diagnosis of acute apical periodontitis is

a. Check for decay, fracture lines, swelling, hyperocclusion or sinus tracts.
b. Patient has moderate to severe pain on percussion.

c. Mobility may or may not be present.
d. Pulp tests are essential and their results must be correlated with other diagnostic information in order to determine if inflammation is of pulpal origin or from occlusal trauma.
e. Radiographs may show no change or widening of periodontal ligament space in some cases.
f. All of the above.

5. Diagnosis of acute periapical abscess is

a. Spontaneous dull, throbbing or persistent pain is present.
b. Tooth is extremely sensitive to percussion.
c. Mobility may be present.
d. On palpation, tooth may be sensitive.
e. Vestibular or facial swelling in seen in these patients.
f. Pulp tests show negative results.
g. All of the above.

6. Indicate ways of exudates evacuation:

a. Through the root canal.
b. Through the dentogingival junction.
c. Through the incision.
d. Through the alveoli.
e. All of the above.

7. Indicate functions of irrigants using in treatment of apical periodontitis

a. Remove dentinal shavings by physical flushing.
b. Increase the efficiency of instruments.
c. Dissolve necrotic tissue.
d. Remove debris from lateral and accessory canals.
e. Germicidal as well as antibacterial properties.
f. Bleaching action.
g. Irrigants with lubricating agent further increase the efficiency.
h. Opening of dentinal tubules by removal of smear layer.
i. All of the above.

8. Technique stages when purulent inflammation periapical tissues during I-st visit include

a. Anesthesia.
b. Operative field isolation.
c. Carious cavity preparation.
d. Evacuation of necrotic tissues from the root canal.

e. Opening of the root canal apex.
f. Cleaning of the root canal with antiseptics.
g. Leaving the tooth open.
h. All of the above.

9. Technique stages when purulent inflammation periapical tissues during II-nd visit include

a. Widening and cleaning of root canal.
b. Drying of root canals.
c. Temporary filling root canals.
d. All of the above.

10. Technique stages when purulent inflammation periapical tissues during III-rd visit include

a. Removing of the temporary filling.
b. Cleaning of root canals with antiseptics.
c. Drying of root canals.
d. Filling of root canals.
e. Tooth restoration.
f. All of the above.

LESSON 11.CLINICAL MANIFESTATION, DIAGNOSTICS, TREATMENT METHODS OF CHRONIC APICAL PERIODONTITIS

The questions to be studied for the learning of the topic:

1. Apical periodontitis, definition, classification.
2. Etiology of chronic periodontitis.
3. Diagnosis of periradicular pathologies.
4. Chronic apical periodontitis. Apical granuloma.
5. Periapical abscess with sinus.
6. Periapical abscess without sinus.
7. Radicular cyst.

Question 1. Apical periodontitis, definition, classification

Apical periodontitis (chronic periradicular periodontitis, asymptomatic periapical periodontitis) is an inflammatory disorder of periradicular tissues caused by irritants of endodontic origin, mostly of persistent microbes living in the root canal system of the affected tooth. It is primarily a disease of infection. But unlike classical infectious diseases of single, specific etiologic agents, apical periodontitis is caused by a consortium of microbial species living in the root canal in an ecologically balanced community form of Iiving4 referred to as biofilms.

According to ICD there are following forms of chronic diseases in the periapical tissues:

K04.5 Chronic apical periodontitis

Apical granuloma

K04.6 Periapical abscess with sinus

Includes: dental abscess with sinus
dentoalveolar abscess with sinus
periodontal abscess of pulpal origin
K04.60 Sinus to maxillary antrum
K04.61 Sinus to nasal cavity
K04.62 Sinus to oral cavity
K04.63 Sinus to skin
K04.69 Periapical abscess with sinus unspecified

K04.7 Periapical abscess without sinus

Dental abscess without sinus
Dentoalveolar abscess without sinus
Periodontal abscess pulpal origin without sinus
Periapical abscess with no reference to sinus

K04.8 Radicular cyst

Question 2. Etiology of chronic periodontitis

Untreated pulpal infection leads to total pulp necrosis. If left untreated, irritants leak into periapical region forming periapex pathologies.

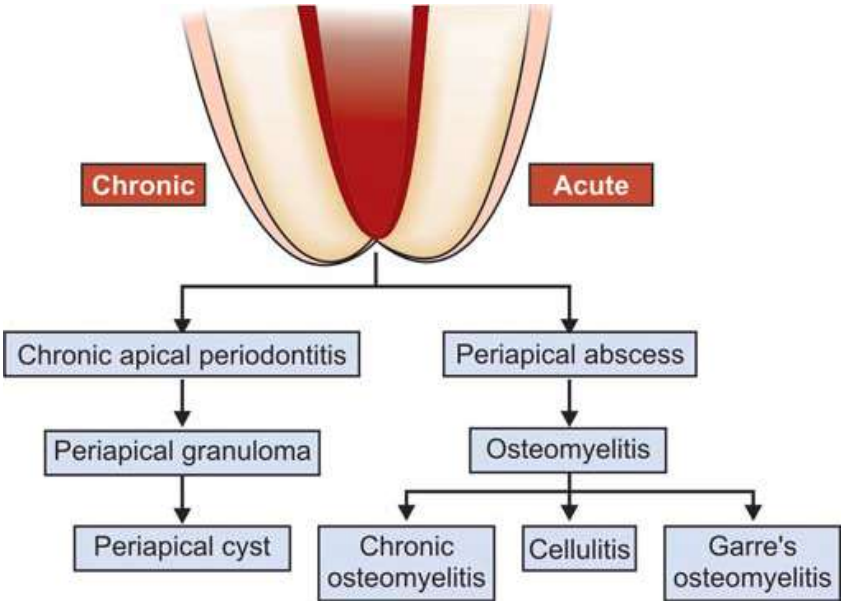


Figure 25. Periapex pathologies

Severity of periapical inflammation is related to microorganisms in root canals and the length of exposure to infecting microorganisms. Microorganisms may invade pulp from periodontal pocket and accessory canals leading to development of lesion of endodontic origin. Root canal is unique, stringent ecological niche for bacterial growth because of lack of oxygen. For bacteria present here the primary nutrient sources is host tissues and tissue fluids.

Microorganisms in chronically infected root canals are mainly anaerobic and gram-negative type. Most common microorganisms are:

- Streptococcus
- Peptostreptococcus
- Provotella
- Porphyromonas
- Enterococcus
- Campylobacter
- Fusobacterium
- Eubacterium
- Propionibacteritum.

Trauma. Physical trauma to tooth, or operative procedures which results in dental follicle desiccation or significant heat transfer cause

sufficient damage to pulp and its blood supply. It results in inflammation with immediate response involving the production of endogenous inflammatory mediator, which cause increase in vascular permeability, stasis and leukocyte infiltration

In cases of severe trauma to tooth resulting in immediate interruption of blood supply, pulp becomes necrotic but is not infected.

Persistent periapical tissue compression from traumatic occlusion leads to apical inflammatory response

Factors Related to Root Canal Procedures. Several complications can arise from improper endodontic technique which can cause periapical diseases:

1. It is impossible to extirpate pulp without initiating an inflammatory response because a wound is created.
2. Using strong or excessive amounts of intracanal medicaments between appointments may induce periapical inflammation.
3. Improper manipulation of instruments within root canal or over instrumentation can force dentinal debris, irrigating solution and toxic components of necrotic tissue in the periapex.
4. Over extended endodontic filling material may induce periapical inflammation by directly inducing foreign body reaction which is characterized by presence of leukocyte infiltration, macrophages and other chronic inflammatory cells.

Question 3. Diagnosis of periradicular pathologies

1. Chief complaint: if any, how long, symptoms, duration of pain, location, onset, stimuli, relief, referred, medications.
2. Dental history*. Recurring episodes of pain, swelling with discharge, swelling which reduces on its own.
3. Objective examination
   - Extraoral examination: general appearance. skin tone, facial asymmetry, swelling, extraorul sinus, sinus tract, tender or enlarged cervical lymph nodes,
   - Immortal examination: it includes examination of soft tissues and teeth to look for discoloration, abrasion, caries, restoration etc.
4. Clinical periapical tests
   - Percution: Indicates inflammation of periodontium.
   - Palpation: Determines how far the inflammatory process has extended periapically.
   - Pulp vitality thermal test which can be heat or cold
   - Electrical pulp testing.
5. Periodontal examination: it is important because periapical and periodontal lesion may mimic each other and require differentiation.

- Probing: determines the level of connective tissue attachment. Probe can penetrate into an inflammatory periapical lesions that extends cervically.
- Mobility: Determines the status of periodontal ligament.

6. Radiographic examination: periradicular lesions of pulpal origin have four characteristics:
   - Loss of lamina dura apically.
   - Radiolucency at apex regardless of cone angle.
   - Radiolucency resembles a hanging drop.
   - Cause of pulp necrosis is usually evident.

   Recent advances:
   - Digital subtraction radiography
   - Xeroradiography
   - Digital radiometric analysis
   - Computed tomography
   - Radiovisiography
   - Magnetic resonance imaging.

Radiographic analysis is necessary for the final diagnosis. In the case of asymptomatic apical periodontitis the patients don't have any complaints.

The disease is often detected only due to X-ray examination. X-ray examination is used:

- ✓ to identify hidden cavities: on the contact surfaces of teeth; under artificial crowns; identification of other inaccessible for inspection foci, which contribute to the development of pulp inflammation (periodontal pocket, etc..).
- ✓ to determine: the depth of caries; the proximity of the cavity bottom to the pulp; the proximity of the filling material to the pulp, etc.
- ✓ for differential diagnosis of: caries; pulpitis; apical periodontitis.
- ✓ in case of teeth or jaws injury, which can lead to the pulp inflammation.

X-ray examination is carried out in several projections. It allows:

- ✓ evaluate anatomical and pathological changes in the pulp and periapical tissues,
- ✓ roughly estimate the length of the root canal;
- ✓ determine the radius of curvature of the root canal;
- ✓ assess the quality of the previous endodontic treatment.

Periapical inflammatory processes that causes changes in the periapical bone, mainly bone loss, which will appear as periapical radiolucencies in radiograph.

Changes of bone texture are the earliest radiographic signs of apical periodontitis. However, these changes may be difficult to assess, and a widening of the periodontal ligament space in the periapical region is usually considered as the most reliable initial sign.

Radiographically, a periapical granuloma or periapical cyst are seen as a round or oval radiolucency that extends away from the apical portion of the root of the tooth.

A definite diagnosis of periapical granuloma or cyst can be made of only after microscopic examination of biopsy material.

A fistula should, therefore, always be traced with a radiopaque object for instance, a gutta-percha point, to determine the tooth of origin radiographically.

Thus, endodontic diagnosis is based on patient complaints, medical history, clinical examination, radiographic examination and clinical test data. The diagnosis is formulated on the basis of the classification, as a rule, adopted in the system of health care institutions.

Question 4. Chronic apical periodontitis. Apical granuloma

Apical granuloma is one of the most common complication of pulpitis. It is usually described as a mass of chronically inflamed granulation tissue found at the apex of non-vital tooth.

Figure 26. Apical granuloma

Clinical features

In the most of the cases are asymptomatic but sometimes pain and sensitivity is seen when acute exacerbation occurs.

1. Tooth is not sensitive to percussion
2. No mobility
3. Soft tissue overlying the area may / may not be tender
4. No response to thermal pulp test
5. Using of endodontic instrument in the root canal is painless.

6. Changes in the oral mucosa in the region of causal tooth can present (swelling, fistula).
7. Threshold values of amperage after electric pulp testing are more than 100 uA.
8. Mostly, lesions are discovered on routine radiographic examination.

Radiographic features

-Mostly discovered on routine radiographic examination

-The earliest change in the periodontal ligament is found to be thickening of ligament at the root apex

-Lesion may be well circumscribed or poorly defined

-Size may vary from small lesion to large radiolucency exceeding more than 2 cm in diameter

-Some amount of root resorption has been reported.

Figure 27. Apical granuloma along of root of carious molar

Radiographically detectable lesions at the apical/periapex or lateral region in the setting of a root canal treated tooth may have failed to resolve for several reasons:

- residual cyst formation;
- persistent pulpal infection;
- extraradicular infection (usually localized periapical actinomycotic colonization);
- accumulation of endogenous debris (e. g., cholesterol crystals);
- periapical foreign material;
- associated periodontal disease;
- penetration of the adjacent maxillary sinus;
- fibrous scar formation.

Histopathologic features

1. It consists of inflamed granulation tissue that is surrounded by a fibrous connective tissue wall
2. The granulation consists of dense lymphocytic infiltrate which further contains neutrophils, plasma cells, histiocytes and eosinophils.
3. Sometime Russel bodies may also be present.

Treatment and prognosis. Main objective in treatment is to reduce and eliminate offending organisms and irritants from the periapical area.

- root canal therapy is preferred (conservative treatment)
- apex resection, hemisection (surgical-conservative treatment)
- in non-restorable tooth, extraction followed by curettage of all apical soft tissue.

Question 5. Periapical abscess with sinus

Sinus (fistula) is a typical sign of this form of disease. The fistulous tract is the communication between periodontal abscess and oral or facial skin surface.

Figure 28.Fistula

The fistulous tract is produced by acute inflammation or exacerbation of chronic apical periodontitis. It can also be formed without prior clinical manifestations.

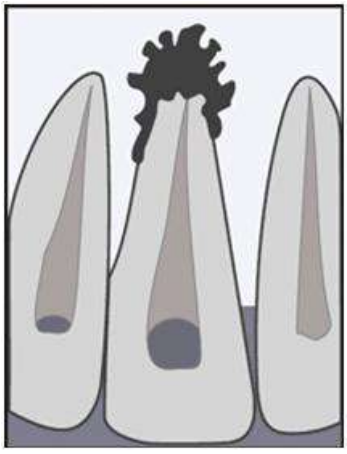


Figure 29. Scheme of periapical abscess with sinus

After opening the abscess, fistula may temporarily close and epithelialization can occur. However, in the case of reaccumulation of fluid in the periapical tissues the fistula is reopened. This condition can be asymptomatic and go undetected by the patient.

When the fistula closes a small scar may remain on the skin or mucosa. In a chronic apical abscess, the abscess has formed a communication through which it discharges. Such communications may be through an intraoral sinus or, less commonly, extraorally. Alternatively the discharge may be along the periodontal ligament; such cases resemble a periodontal pocket. Usually these communications or tracts heal spontaneously following root canal therapy or extraction.

Symptoms: affected teeth do not respond to pulp sensitivity tests. Tenderness to biting is usually mild; however some tenderness may be noted to palpation over the root apex.

Radiographic appearance is varied, ranging from minimal widening of the periodontal ligament space to a large area of destruction of periapical tissues.

Figure 30. X-ray in periapical abscess with sinus

Treatment: root canal therapy, apex resection, hemisection or extraction.

Question 6. Periapical abscess without sinus

Signs and symptoms: it varies from moderate discomfort or swelling to systemic involvement, such as elevated temperature and malaise. Involved teeth are usually tender to both palpation and percussion.

Radiographic changes are variable depending on the amount of periradicular destruction, which already has present; however, usually there

is a well-defined radiolucent area, as in many situations an acute apical abscess is an acute exacerbation of a chronic situation.

Figure 31. Possible X-ray in periapical abscess without sinus

Treatment: initial treatment of an acute apical abscess involves removal of the cause as soon as possible. Drainage should be applied either by opening the tooth or making an incision into a related swelling. An antibiotic may be prescribed, depending on the patient's condition. Once the acute symptoms have subsided, then root canal therapy or extraction may be performed.

7. Radicular cyst

The radicular cyst is an inflammatory cyst which results because of extension of infection from pulp into the surrounding periapical tissues.

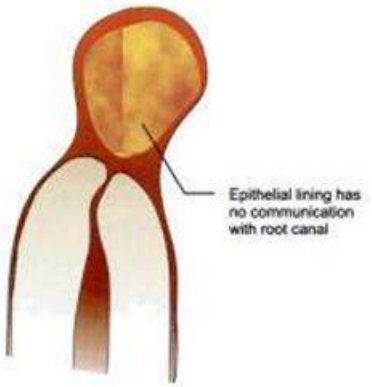


Figure 32. Apical cyst

Clinical features

1. The cyst is frequently asymptomatic and sometimes it is discovered when periapical radiographs are taken of teeth with non-vital pulps.
2. Incidence: males are affected more than females; age - peak incidence in third or fourth decades; site - highest in anterior maxilla
3. In mandibular posterior teeth, separate small cysts arise from each apex of multi-rooted teeth
4. Slowly enlarging swelling sometimes attains a large size.
5. As the cyst enlarges in size, the covering bone becomes thin in size and exhibits springiness due to fluctuation.
6. In maxilla, palatal expansion is mainly seen in ease of maxillary lateral incisor.
7. The involved tooth / teeth usually found to be non-vital, discolored, fractured or failed root canal.

Radiographic features. Radiographically radicular cyst appears as round, pear or ovoid shaped radiolucency outlined by a narrow radioopaque margin.

Figure 33. Radicular cyst

Treatment. Different options for management of residual cyst are:

- ✓ -Endodontic treatment
- ✓ -Apicoectomy
- ✓ -Extraction (severe bone loss).

Tests to the topic

1. What microorganisms may invade pulp from periodontal pocket and accessory canals leading to development of lesion of endodontic origin?

a. Streptococcus.
b. Peptostreptococcus.
c. Provotella.

d. Porphyromonas.
e. Enterococcus.
f. Campylobacter.
g. All answers are right.

2. What are the main etiological factors of the apical lesions development?

a. Trauma.
b. Microorganisms.
c. Bruxism.
d. All answers are right.

3. What factors related to root canal procedures may induce periapical inflammation?

a. Using strong or excessive amounts of intracanal medicaments.
b. Improper manipulation of instruments within root canal or over instrumentation.
c. Over extended endodontic filling material.
d. All answers are right.

4. What are the recent advances in x-ray examination of periapical tissues?

a. Digital subtraction radiography.
b. Digital radiometric analysis.
c. Computed tomography.
d. Magnetic resonance imaging.
e. All answers are right.

5. What are the clinical periapical tests?

a. Percution.
b. Palpation.
c. Probing.
d. Radiographic examination.
e. Dental history.

6. What are the clinical features of chronic apical periodontitis?

a. Tooth is not sensitive to percussion.
b. Tooth is sensitive to percussion.
c. No response to thermal pulp test.
d. Using of endodontic instrument in the root canal is painless.
e. Teeth are mobile.

7. What are the radiographic features of chronic apical periodontitis?

a. The earliest change in the periodontal ligament is found to be thickening of ligament at the root apex.
b. Lesion may be well circumscribed or poorly defined.
c. Size may vary from small lesion to large radiolucency exceeding more than 2 cm in diameter.
d. All answers are right.

8. What kinds of treatment of chronic apical periodontitis do you know?

a. Root canal therapy is preferred (conservative treatment).
b. Apex resection, hemisection (surgical-conservative treatment).
c. In non-restorable tooth, extraction followed by curettage of all apical soft tissue.
d. All answers are right.

9. What are the clinical features of radicular cyst?

a. The cyst is frequently asymptomatic.
b. The cyst is usually characterized by pain in biting.
c. In mandibular posterior teeth, separate small cysts arise from each apex of multi-rooted teeth.
d. Slowly enlarging swelling sometimes attains a large size.
e. All answers are right.

10. What are the radiographic features of radicular cyst?

a. Appears as round, pear or ovoid shaped radiolucency outlined by a narrow radioopaque margin.
b. No radiographic changes.
c. Thickening of ligament at the root apex.
d. All answers are right.

LESSON 12.MECHANICAL TREATMENT OF ROOT CANALS. STAGES OF ENDODONTIC TREATMENT. RULES OF WORK WITH THE ENDODONTIC INSTRUMENTS

The questions to be studied for the learning of the topic:

1. The basic stages of endodontic treatment.
2. Instrumentation of root canal, definition, goals and tasks, stages.
3. Basic principles of canal instrumentation.
4. Endodontic instruments, classification and standardization.
5. Hand operated instruments.
6. Machine Ni-Ti instruments.
7. Rules of work with the endodontic instruments.

Question 1. The basic stages of endodontic treatment

There are three basic phases in endodontic treatment. First is the diagnostic phase in which the disease to be treated is determined and the treatment plan developed. The second is the preparatory phase, when the contents of the root canal are removed and the canal prepared for the filling material. The third involves the filling or obliteration of the canal to gain a hermetic (airtight) seal as close as possible to the cement-dentinal junction with an inert material. The dental specialist plays a key role in the successful completion of all three phases by having the necessary equipment ready at the appropriate time.

Diagnosing. All root canal therapy begins with a diagnosis. First, the dental officer takes an oral history of the patient's particular problem. The dentist should enter the patient's chief complaint on the record. The chief complaint should be written in the patient's own words. Next, a clinical examination should be performe. The dentist should provide the basic examination setup for dental officer. When the offending tooth or area is located, a periapical radiograph is taken to aid in the diagnosis. Frequently, a radiograph will not reveal any definite pathology. In this case, the d should bntiste prepared to provide the dental officer with auxiliary diagnostic aids. The electric pulp tester and warm and cold thermal tests are the most commonly used auxiliary diagnostic aids.

Preparing the canal. Once the diagnosis is made, local anesthesia may be administered by the dental officer. The rubber dam is applied and the area of the rubber dam around the affected tooth is swabbed with an iodophor or alcohol disinfectant. The dental officer uses a high-speed handpiece to create an occlusal or lingual opening into the pulp chamber of the tooth. The slow-speed handpiece may be used to refine the shape and size of the opening. Next, a barbed broach may be used to remove the pulp tissue. At this point, a small file fitted with a rubber stop is placed in the root canal and the dental

specialist takes a periapical radiograph of the tooth containing the stoppered file. This is referred to as the trial-file radiograph and is used to determine the correct working length of the files used. Once the working length is determined by the dental officer, all files used will be measured with the endodontic ruler and stoppered at the correct working length. The working length, expressed in millimeters, should be recorded in the patient's treatment record. Using reamers and files of increasing size stoppered to the correct working length, the root canal can be gradually shaped and enlarged. During the filing, the canal is irrigated to provide lubrication and a flushing action on the debris. Sodium hypochlorite (3 percent solution) is usually the irrigant used, and is administered with a large plastic syringe. When filing is completed, small paper points are used to dry the root canal.

Filling and sealing the canal. When the dental officer has determined that the root canal is sufficiently enlarged, he will select and trial-fit a gutta-percha point or silver point of the same size as the last file used. Once the point passes the trial fit, it is ready to be cemented. The dental specialist mixes the root canal sealer. The point is coated with the sealer and seated into place. Depending on the technique, a plugger or a spreader, or both, is used to condense the gutta-percha in the root canal. When the root canal has been filled satisfactorily, a thick mix of sealer is made and plugged into the access area to completely seal the canal. After X-ray control tooth restoration is performed.

Question 2. Instrumentation of root canal, definition, goals and tasks, stages

Preparation of the root canal system is recognized as being one of the most important stages in root canal treatment. It includes the removal of vital and necrotic tissues from the root canal system, along with infected root dentine and, in cases of retreatment, the removal of metallic and non-metallic obstacles. It aims to prepare the canal space to facilitate disinfection by irrigants and medicaments. Thus, canal preparation is the essential phase that eliminates infection. Prevention of reinfection is then achieved through the provision of a fluid-tight root canal filling and a coronal restoration.

Mechanical instrumentation of the root canal system is an important phase of root canal preparation as it creates the space that allows irrigants and antibacterial medicaments to more effectively eradicate bacteria and eliminate bacterial byproducts. However, it remains one of the most difficult tasks in endodontic therapy. In the literature various terms have been used for this step of the treatment including instrumentation, preparation, enlargement, and shaping.

The major goals of root canal preparation are the prevention of periradicular disease and/or promotion of healing in cases where disease already exists through:

1. Removal of vital and necrotic tissue from the main root canal(s).
2. Creation of sufficient space for irrigation and medication.
3. Preservation of the integrity and location of the apical canal anatomy.
4. Avoidance of iatrogenic damage to the canal system and root structure.
5. Facilitation of canal filling.
6. Avoidance of further irritation and/or infection of the periradicular tissues.
7. Preservation of sound root dentine to allow long- term function of the tooth.

Schilder described five root canal design ***objectives***:

1. Continuously tapering funnel from the apex to the access cavity.
2. Cross-sectional diameter should be narrower at every point apically.
3. The root canal preparation should flow with the shape of the original canal.
4. The apical foramen should remain in its original position.
5. The apical opening should be kept as small as practical.

And four biologic objectives:

1. Confinement of instrumentation to the roots themselves.
2. No forcing of necrotic debris beyond the foramen.
3. Removal of all tissue from the root canal space.
4. Creation of sufficient space for intracanal medicaments.

Preparatory phase steps:

1) isolation from saliva;
2) access to the root canals;
3) evacuation of infected tissue from the root canal;
4) root canal preparation;
5) root canal irrigation;
6) root canal length determination.

Question 3. Basic principles of canal instrumentation

1. There should be a straight line access to the canal orifices. Creation of a straight line access by removing overhang dentine influence the forces exerted by a file in apical third of the canal
2. Files arc always worked with in a canal filled with irrigant, so copious irrigation is done between the instrumentation, i.e. canal must always be prepared in wet environment
3. Preparation of canal should be completed while retaining its original form and the shape

4. Exploration of the orifice is always done with smaller file to gauge the canal size and the configuration.
5. Canal enlargement should be done by using instruments in the sequential order without skipping sizes.
6. All the working instruments should be kept in confines of the root canal to avoid any procedural accidents.
7. Instrument binding or dentin removal on insertion should be avoided.
8. After each insertion and removal of the tile, its flutes should be cleaned and inspected
9. Smaller number instruments should be used extravagantly.
10. Recapitulation is regularly done to loosen debris by returning to working length. The canal walls should not be enlarged during recapitulation.
11. Over preparation and too aggressive over enlargement of the curved canals should be avoided.
12. Creation of an apical stop may be impossible if apical foramen is already very large. Overusing of larger files should be avoided in such cases as it may create even a larger apical opening.
13. Never force the instrument in the canal. Forcing or continuing to rotate an instrument may break the instrument.
14. Establish the apical patency before starting the biomechanical preparation of tooth. Apical patency of the canal established and checked, by passing a smaller number file (No 10) across the apex. The aim is to allow for creation of a preparation and tilling extending fully to the periodontal ligament. Establishing the patency is considered a non-harmful even considering the blood supply and immune response present in the periapical area.

Question 4. Endodontic instruments, classification and standartization

Although variety of instruments used in general dentistry, are applicable in endodontics, yet some special instruments are unique to endodontic purpose.

Classification of endodontic instruments

ISO – FDI (Federation Dentaire International) grouped root canal instruments according to their method of use:

Table 20. **Classification of endodontic instruments**

Group I	*Hand use only* for example, K and H-files, reamers, broaches, etc.
Group II	*Latch type Engine driven*: Same design as group I but can be attached to handpiece.
Group III	*Drills or reamers latch type engine driven* example, Gates-Glidden, Peeso reamers.

Group IV	Root canal points like gutta-percha, silver point, paper point.

Grossman's Classification grouped root canal instruments according to their function and purpose. Instruments are divided into four groups.

Table21. **Grossman's Classification**

1. Exploring Instruments	To locate the canal orifice or to assist in obtaining patency of the root canal - Smooth barbed broach - DG-16 explorer.
2. Debriding Instruments	To extirpate the pulp and to remove debris and other foreign materials Barbed broach.
3. Shaping Instruments	To shape root canal apically and laterally - Reamers - Files.
4. Obturating Instruments	To pack gutta-percha into root canal - Plugger - Spreaders - Lentulo spirals.

Table22. **Harty's Classification**

1. Instrument for access cavity preparation	- Basic instrument pack - Burs - Rubber dam.
2. Instruments for root canal preparation	- Hand instruments - Power assisted root canal instruments - Electronic canal measuring device - Measuring instruments, gauges and stands - Instruments for retrieving broken instruments and posts.
3. Instruments for filling root canals	- Lateral condensation - Vertical condensation - Hybrid technique - Thermoplasticized gutta-percha.
4. Equipments for storing instruments	
5. Sterilization of endodontic instruments	
6. Equipments for improving visibility.	

A hand operated instrument reamer or file begins as a round wire which is modified to form a tapered instrument with cutting edges. Several shapes

and forms of such instruments are available. These are manufactured by two techniques:

a) By machining the instrument directly on the lathe for example H-file and Ni-Ti instruments are machined.
b) By first grinding and then twisting. Here the raw wire is ground into tapered geometric blanks, i.e. square, triangular or rhomboid. These blanks are then twisted counterclockwise to produce cutting edges.

Ingle and LeVine using and electronic microcomparator found variation in the diameter and taper for same size of instrument. They suggested few guidelines for instruments for having uniformity in instrument diameter and taper. The guidelines were:

1. Instruments are numbered from 10 to100. Each number represent diameter of instrument in 100th of millimeter at the tip.

2. Working blade begins at tip (D1) and extends 16 mm up the shaft (D2). D2 is 0.32 mm greater than D1 ensuring that there is constant increase in taper, i.e. 0.02 mm per mm of instrument.

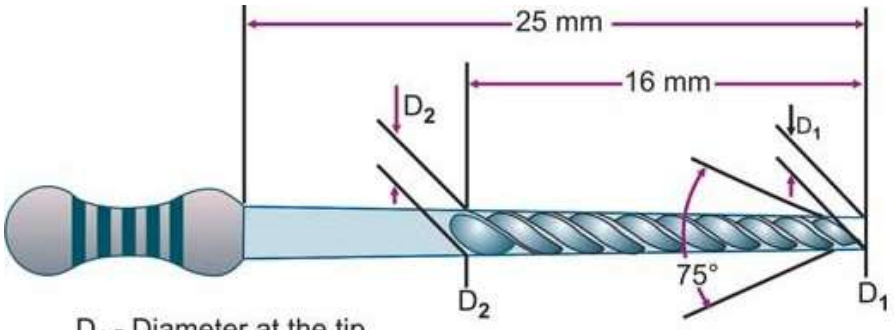


Figure 34. Hand instrument

3. Tip angle of instrument varies as 75±15°.

4. Instruments handles are color coded for their easier recognition (Pink, grey).

5. Instruments available in length 21. 25. 28 and 30 mm are used for root canal therapy, and those of 40 mm size are used in preparing root canals for the endodontic implants.

To determine the type of instrument, the symbols are also used. They are represented on the instrument handle.

color	Color code	New number	diameter	
			At tip	At 16mm
	Pink	6	0.06	0.38
	Gray	8	0.08	0.40
	Purple	10	0.10	0.42
	White	15	0.15	0.47
	Yellow	20	0.20	0.52
	Red	25	0.25	0.57
	Blue	30	0.30	0.62
	Green	35	0.35	0.67
	Black	40	0.40	0.72
	White	90	0.90	1.22
	Yellow	100	1.00	1.32
	Red	110	1.10	1.42
	Blue	120	1.20	1.52
	Green	130	1.30	1.62
	Black	140	1.40	1.72
	White	150	1.50	1.82

Figure 35. Color coding of endodontic instruments

Tool name	Symbol
K - reamer	
K – file	
Hedstrem – file	
Rasp	
Canal expander Beutelrock reamer B2	
Canal-expander Beutelrock drillreamer	
Pulp extraction	
Canal filler	

Figure 36. Symbol coding of endodontic instruments

Question 5. Hand operated instruments

Broaches and Rasps

1. They are one of the oldest intracanal instruments with specifications by ANSI No. 63 and ISO No. 3630-1.

2. Broaches and rasps are manufactured from round wires, smooth surface of which has been notched to form barbs.

3. They are specifically designed to remove the pulp.

4. Both have similar design except in taper and barb size. Barb size is larger in broach than rasp.

5. Broach does not cut the dentin but can effectively be used to remove cotton or paper points which might have lodged in the canal.

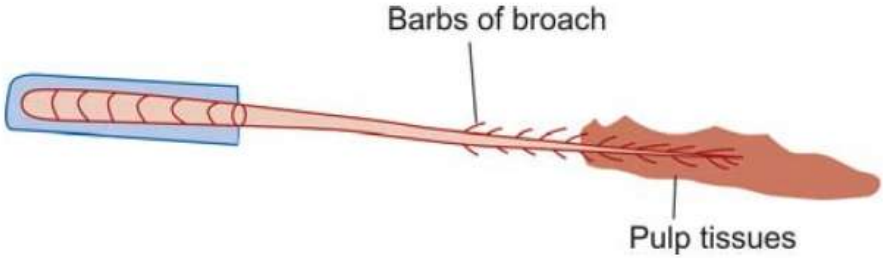


Figure 37. Removal of pulp using broach

6. Broach should not be forced apically into the canal, as its barbs get compressed by the canal wall. While removing this embedded instrument, barbs get embedded into dentin and broach may break on applying pressure.

7. Smooth broach is free of barbs. It is used as pathfinder.

Technique of Pulp Extirpation (Healey, 1984)

- Penetrate the barbed broach along the canal wall towards the apex
- As it reaches to the apical constriction, move it into the center of mass of pulp tissue

Rotate the broach several times in a watch winding manner to entrap the pulp which is then withdrawn from the canal.

Reamers

1. Reamers are K-type instruments (manufactured by Kerr company), which are used to ream the canals. They cut by inserting into the canal, twisting clockwise one quarter to half turn and then withdrawing, i.e. penetration, rotation and retraction.

2. Reamers have triangular blank and lesser number of flutes than files. Numbers of flutes in reamer are 1/2- 1 mm. while in files the flutes are 1/2 - 2 mm.

3. Though reamer has fewer numbers of flutes than file, culling efficiency is same as that of files because more space between flutes causes better removal of debris.

4. Reamer tends to remain self-centered in the canal resulting in less chances of canal transportation.

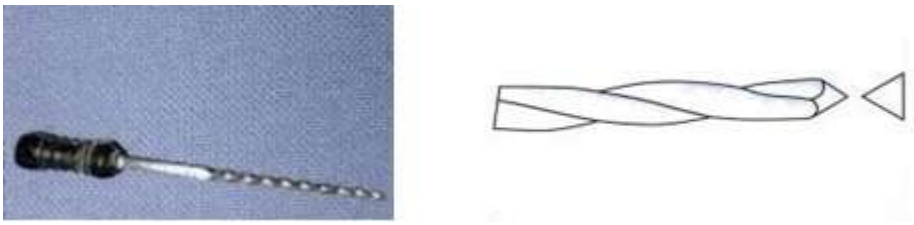


Figure 38. K-Reamer

Files are the instruments used during cleaning arid shaping of the root canals for machining of the dentin. Since Kerr manufacturing company was first to produce them, the files were also called K-files.

Files are predominantly used with filing or rasping action in which there is little or no rotation in the root canals. It is placcd in root canal and pressure is exerted against the canal wall and instrument is withdrawn while maintaining the pressure.

K-File:

1. It is triangular or square in cross section, manufactured from stainless steel wire, which is grounded into desired shape
2. Tighter twisting of the file spirals increases the number of flutes in file (more than reamer).
3. Triangular cross sectioned files show superior cutting and increased flexibility than the file or reamers with square blank.

Figure 39. K-file

K-Flex Files. They were introduced by Kerr manufacturing company in 1982. It was realized that square blank of file results in total decrease in the instrument flexibility. To maintain shape and flexibility of these files K-flex files were introduced.

Figure 40. K-Flex File

K-flex files are rhombus in cross section having two acute angles causing increased sharpness and two obtuse angles which make more space for debris removal. Also the decrease in contact of instrument with canal walls provides more space for irrigation.

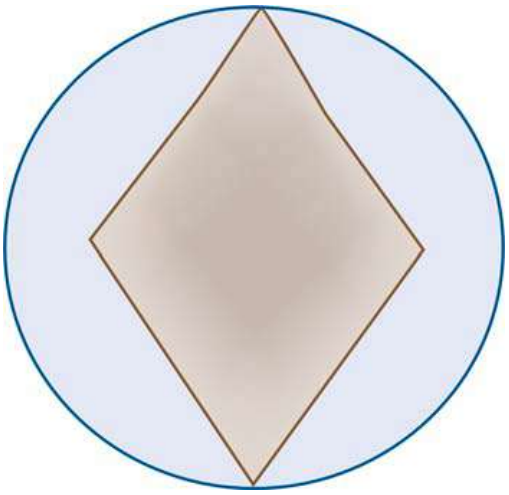


Figure 41. Rombous section of K-Flex File

Flexo File. These are similar to the K-flex files except that they have triangular cross section. This feature provides them more flexibility and thus ability to resist fracture.

Flex-R File. Flex-R files are made by removing the sharp cutting edges from the tip of instrument. This design reduces the ledge formation, canal trans-portation and other procedural accidents when used with balanced force technique. The noncutting lip enables the instrument to traverse along the canal rather than gouge into it. Another feature of flex-R file is presence of triangular cross section which provides it flexibility to be used in curved canals.

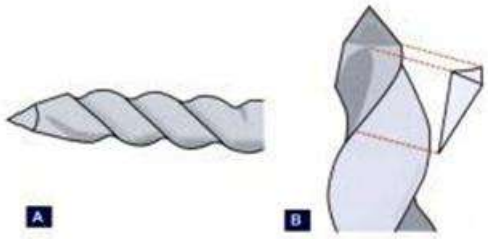


Figure 42. Flex-R File

Hedstrom flies (H-files) have flutes which resemble successively triangles set one on another.

- ✓ They are made by cutting the spiral grooves into round, tapered steel wire in the same manner as wood screws are made. This results in formation of a sharp edge which cuts on removing strokes only.
- ✓ Hedstrom files cut only when instrument is withdrawn because its edges face the handle of the instrument.
- ✓ When used in torquing motion, their edges can engage in the dentin of root canal wall and causing H -files to fracture.

- ✓ Rake angle and distance between the flutes are two main features which determine working of the file.
- ✓ H-Files have positive rake angle, i.e. its cutting edge is turned in the same direction in which the force is applied which makes it dig into the dentin making it more aggressive in cutting.
- ✓ Hedstrom files should be used to machine straight canal s because they are strong and aggressive cutters. Since they lack the flexibility and are fragile in nature, the H-files tend to fracture when used in torquing action. Safety Hedstrom File
- ✓ This file has noncutting safety side along the length of the blade which reduces the chances of perforations. The non-cutting side is directed to the side of canal where cutting is not required. The non-cutting side of safety file prevents lodging of the canals.

Figure 43. H-file

Engine Driven Instrumens Gates Glidden Burs

1. Traditional engine driven instruments include Gates-Glidden drills which have flame shaped cutting point mounted on long thin shaft attached to a latch type shank.
2. 2 Gates-Gliddens are available in a set from 1 to 6 with the diameters from 0.5 to 1.5 mm.
3. Due to their design Gates-Glidden drills are side cutting instruments with safety tips. They should be used at the speed of 75-1500 rpm.
4. If its cutting tip jams against the canal wall, fracture should occur at the junction of shank and the shaft but not at the tip of the instrument. This makes the easy removal of fractured drill from the canal.
5. They can be used both in crown down as well as step back fashion.

Figure 44. Gates Glidden

Uses of Gates-Glidden Drills

1. For coronal flaring during root canal preparation.
2. During retreatment cases or post space preparation for removal of guttapercha.
3. During instrument removal, if used incorrectly for example using at high rpm, incorrect angle of insertion, forceful drilling, the use of Gates-Glidden can result in procedural accidents like perforations, instrument separation, etc.

But nowadays in many ways nickel titanium instruments have replaced the Gates-Glidden.

Figure 45. Use of Gates Glidden for canal preparation

Peeso Reamers. They are rotary instruments used mainly for post space preparations. Disadvantages of using peeso reamers are:

1.They don't follow the canal curvature and may cause perforation by cutting laterally.

2.They are stiff instruments

3.They have to be used very carefully to avoid iatrogenic errors.

Question 6. Machine Ni-Ti instruments

These instruments were introduced in early 1990s, and since then they have become indispensable tools for canal enlargement.

Two of the main characteristics of this alloy, composed of approximately 55% (wt) nickel and 45% (wt) titanium are memory shape and superior elasticity. The elastic limit in bending and torsion is two to three times higher than that of steel instruments. The modulus of elasticity is significantly lower for Ni-Ti alloys than for steel, therefore much lower forces are exerted on radicular wall dentine, compared with steel instruments. These unique properties are related to the fact that Ni-Ti is a so-called 'shape memory alloy', existing in two different crystalline forms: austenite and martensite. Because of the metallic properties of Ni-Ti, it became possible to engineer instruments with greater tapers than 2%, which is the norm for steel instruments.

Before using these instruments one should take cure to have a straight line access to the canal system. Canals should be thoroughly explored and passively enlarged before using rotary instrument. Instruments should be constantly moving and speed of rotation of each instrument should be known.

All of these Ni-Ti rotary systems incorporate:

- Crown down preparation.
- Apical preparation as finale.
- Increasing taper instruments.

Ni-Ti rotary instrumentation should always be performed with slow-speed, low-torque or «right-torque» electric motors. A variety of motors exist from varying manufacturers including the Tecnika ATR and Aseptico ITR both of which were designed specifically for endodontics and are supplied by Tulsa Densply. These types of electronic motors have preprogrammed speed and torque values preset by the manufacturer for their recommended instruments. The units also allow the operator to adjust the manufacturers' settings to the specific needs of the user. An additional benefit to the electric motors is the auto-reverse feature which is activated prior to reaching the elastic torque limit of the file, potentially reducing the possibility of instrument separation.

Figure 46. Electric endomotors

Also available are air driven motors that connect to a slow-speed attachment on the dental unit. The air driven motors are less expensive than the electric motors. However, they are unable to control torque and do not have an auto-reverse feature. The past few years have seen a dramatic increase in the number of manufacturers producing NiTi rotary files. The most popular systems are marketed by Tulsa Dental and Sybron Endo (formally Analytic Technologies). Tulsa markets both the ProSystem GT and ProTaper lines of rotary instruments, where Sybron Endo markets K3 (the successor of the Quantec line of files).

The main features of Ni-Ti instruments using:

- the use of Ni-Ti instruments results in less straightening and better centred preparations of curved root canals,
- use of Ni-Ti instruments alone does not result in complete cleanliness of the root canal walls,
- cleanliness decreases from the coronal to the apical part of the root canal,
- the use of a paste-type chelator during preparation does not remove the smear layer completely,
- the use of Ni-Ti instruments with active cutting blades is superior to instruments with radial lands in terms of root canal cleanliness,
- when used according to the manufacturers' guidelines Ni-Ti instruments seem to be safe to use,
- the use of instruments with safety tips seems to be preferable with respect to working safety,
- the use of a special motor with constant speed, low torque and torque-control is recommended.

There are many techniques of root canal preparation with Ni-Ti instruments.

We consider one of the most common techniques.

ProTaper System. As we have seen that ProTaper files have a triangular cross section and is variably tapered across its cutting length. The progressively tapered design improves flexibility, cutting efficiency and the safety of these files.

The ProTaper system consists of three shaping and three finishing files.

1. Shaping files are termed as Sx, S1 and S2

Sx these are files of shorter length of 19 mm with Do diameter of 0.19 mm and D14 diameter of 1.20 mm. The increase of taper up to D9 and then taper decrease up to D14 increases its flexibility.

S1 has Do diameter of 0.17 mm and D14 of 1.20 mm. it is used to prepare coronal part of the root.

S2 has Do diameter of 0,20 mm and D14 of 1.20 mm. it is used to prepare middle third of the canal.

2. Finishing files F1, F2, F3 are used to prepare and finish apical part of the root canal.

F1 Do diameter and apical taper is 20 and 0.07.

F2 Do diameter and taper is 25 and 0.08.

F3 Do diameter and taper is 30 and 0.09.

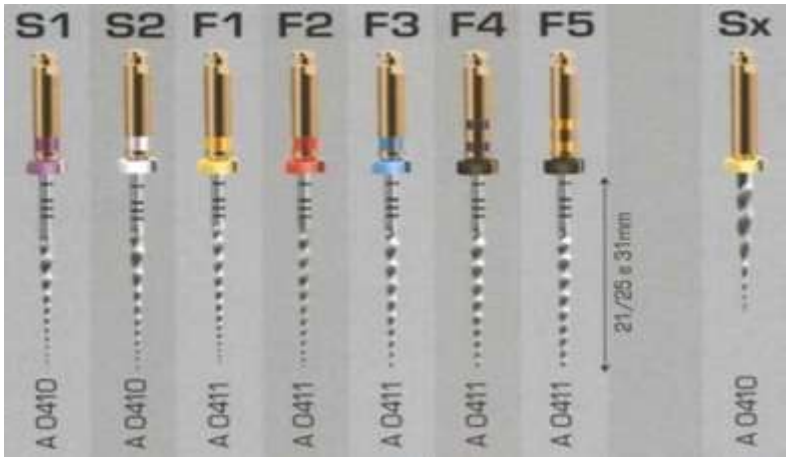


Figure 47. ProTaper System

Profile System

- ✓ Profile instruments made by Tulsa Dental were one of the first Ni-Ti instruments available commercially. This system was introduced by Dr. Johnson in 1944.
- ✓ Earlier Profile system was sold as series 29 instruments. In series 29. at the constant rate of 29 percent, there has advantage of smooth transition among the smaller tiles but in larger files, the greater gap may create difficulties during cleaning and shaping of the root canals. After this

profile series were introduced with greater tapers of 19 mm lengths and ISO sized tips. Recommended rotational speed for profiles is 150-300 RPM.

- ✓ Cross section of profiles show three equally shaped U-shaped grooves with radial lands.
- ✓ Central parallel core present in profiles increase their flexibility.
- ✓ They have negative rake angle (-20°) which makes them to cut dentin in planning motion. Profile instruments tend to pull debris out of the canal because of presence of 20° helical angle.

Figure 48. Profile

Greater Taper Files (GT Files)

1. The GT rotary instruments possess a U-shaped file design with ISO tip sizes of 20, 30 and 40 and tapers of 0.04, 0.06, 0.08, 010 and 0.12.
2. Accessory GT files for use as orifice openers of 0.12 taper in ISO sizes of 35, 50, 70 and 90 are also available.
3. The maximum diameter of these instruments is 1,50 mm.
4. Recommended rotational speed for GT files is 350 rpm.
5. Negative rake angle of these files makes them to scrape the dentin rather than cutting it.

Quantec System

1. Quantec file series are available in both cutting and noncutting lips with standard size of 25 No. in 0.12., 0.10. 0.08., 0.06., 0.05., 0.04., 0.03 and 0.02 tapers. 0.02 tapered Quantec file are also available in size 15-60 No.
2. Quantec system has a positive blade angle with two wide radial lands and relief behind the lands. 3. This unique design minimizes its contact with the canal, thereby reducing the torque, also this design increases the strength of the instrument.
3. Quantec system utilizes the "graduated taper technique" to prepare a canal. It is thought that using a series of files of single taper result in the decreases efficiency as the larger instruments are used. This happens because more of file comes in contact with the dentinal wall which makes it more difficult to remove dentin. Thereby retarding the proper cleaning and shaping of the canal. But in graduated taper technique, restricted contact of area increases the efficiency of the instrument because now forces are concentrated on smaller area.

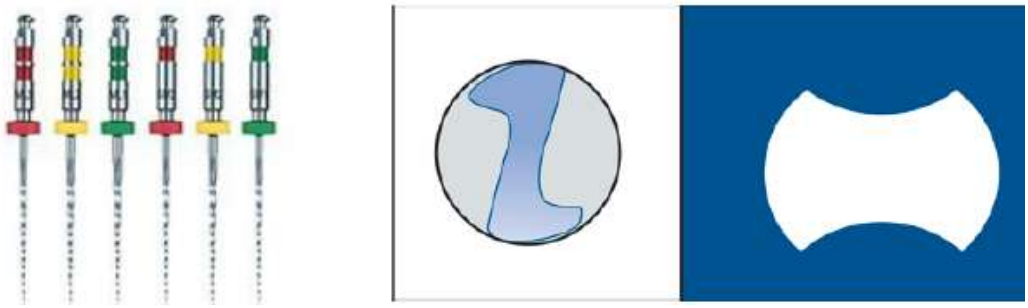


Figure 49. Quantec Files

K3 Rotary File System. Dr. John Mc. Spadden in 2002 in North America introduced K3 system.

1. K3 files are available in taper of 0.02,0.04 or 0.06 with ISO tip sizes. An Axxess handle design shortens the file by 5 mm without affecting its working length.
2. They are flexible because of presence of variable core diameter.
3. Cutting head of K3 system show three radial lands with relief behind two radial lands. Asymmetrically placed flutes make the K3 system with superior canal tracking ability, add peripheral strength to K3 system, and prevent screwing into the canal.
4. K3 files have positive rake angle providing them an effective cutting surface.
5. They are color coded to differentiate various tip sizes and tapers.
6. Body shapers available in taper 0.08, 0.10 and 0.12 all with tip size 0.25, are used to prepare the coronal third of the canal.

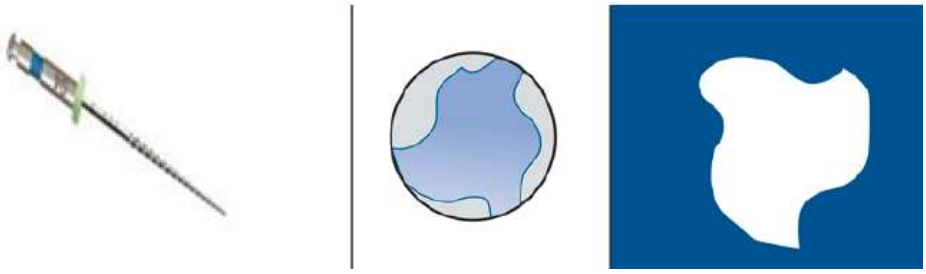


Figure 50. K3 Files

HERO 642 is used in «Crown down» technique, between 300 and 600 rotations per minute (rpm) in a standard slow speed contra angle air driven or electric motors.

Features:

1. It has trihelical Hedstrom design with sharp flutes.
2. Due to progressively increasing distance between the flutes-reduced risk for binding of the instrument in root canal.
3. Larger central core - provides extra strength.
4. Used at speed - 300 - 600 rpm.

5. Available in size - 0.20 - 0.45.

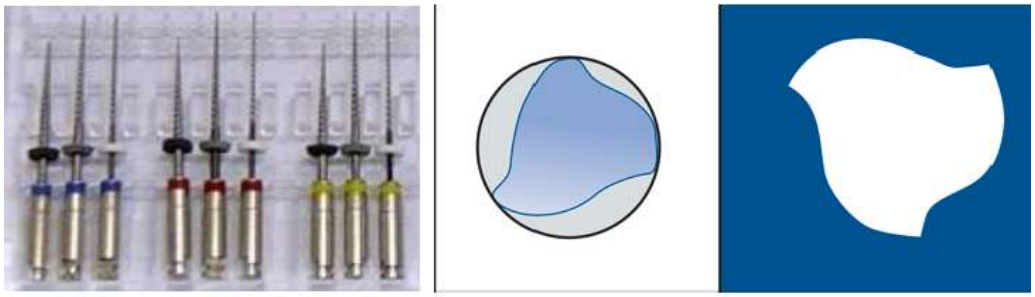


Figure 51. HERO 642 Files

Question 7. Rules of work with the endodontic instruments

Reaming. Ream indicates use of sharp edged tool for enlarging holes. In endodontic practice, reaming is commonly done by use of reamers , though files can also be used. It involves clockwise rotation of an instrument. The instrument may be controlled from insertion to generate a cutting.

Filing. The term filing indicates push-pull motion with the instrument. This method is commonly used for canal preparation.

Combination of Reaming and Filing. In this technique, the file is inserted with a quarter turn clockwise and apically directed pressure (i.e. reaming) and then is subsequently withdrawn (i.e. filing).

Balanced Force Technique. This technique involves oscillation of instrument right and left with different arcs in either direction. Instrument is first inserted into the canal by moving it clockwise with one quarter turn. Then cut dentin; the file is rotated counter clockwise and simultaneously pushed apically to prevent it from backing out of the canal. Finally, the file is removed by rotating file clockwise simultaneously pulling the instrument out of the canal. This technique offers most efficient dentin cutting but care should be taken not to apply excessive force with this technique because it may lock the instrument into the canal.

Watch Winding. It is back and forth oscillation of the endodontic instrument (file or reamer) right and left as it is advanced into the canal. The angle of rotation is usually 30 to 60 degrees. This technique is efficient with K-type instruments. Basically, there are two approaches used for biomechanical preparation, either starting at the apex with fine instruments and working up to the orifice with progressively larger instruments, — this is Step back technique, or starting at the orifice with larger instruments and working up to apex with larger instruments, — this is Crown down technique.

Rules of work with the Ni-Ti endodontic instruments

1. Use only torque controlled electric handpiece for these instruments.

2. Proper glide path must be established before using rotary tiles, i.e. getting the canal to at least size 15 before using them.
3. Use crown down method for canal preparation. By this apical curves can be negotiated safety.
4. Frequent cleaning of flutes should be done as it can lessen the chances that debris will enter the microfractures and resulting in propagation of original fracture and finally the separation.
5. Do not force the file apically against resistance. Motion of file going into canal should be smooth, deliberate with 1-2 mm deep increments relative to the previous instrument.
6. Remove the maximum possible pulp tissue with broach before using rotary files.
7. Canals should be well lubricated and irrigated. This reduces the friction between instrument and the dentinal walls.
8. Dentin mud collected in the canal increases the risk of fracture, it should be cleared off by frequent irrigation.
9. Discard a file if it is bent, stretched or has a shiny spot.
10. Do not use rotary nickel titanium files to tnue working length specially in teeth with S - shaped canals, canals with multiple and sharp curves and if there is difficult access of orifice because it can place stresses on the instrument which will cross the breaking torque value. In such cases apical portion of canal should be prepared by hand files.
11. A file should be considered disposable when:
    - ✓ It has been used in cursed canals.
    - ✓ Despite of existence of excellent glide path, if it doesn't cut dentin properly.

Tests to the topic

1. What are the main stages of the endodontic treatment?

a. Diagnosing.
b. Preparing the canal.
c. Filling and sealing the canal.
d. All answers are right.

2. The major goals of root canal preparation are:

a. Removal of vital and necrotic tissue from the main root canal(s).
b. Preservation of the integrity and location of the apical canal anatomy.
c. Facilitation of canal filling.
d. Avoidance of iatrogenic damage to the canal system and root structure.
e. All answers are right.

3. ISO – FDI grouped root canal instruments according to:

a. Their method of use.
b. To their function and purpose.
c. All answers are right.

4. What applies to hand endodontic instruments?

a. Reamers.
b. Broaches and Rasps.
c. Files.
d. Pro Files.
e. Quantec.
f. K-Flex Files.

5. K-Flex File has:

a. Rombous section.
b. Round section.
c. Square section.
d. All answers are right.

6. S-file has:

a. Rombous section.
b. Round section.
c. «S» shape in the cross section.
d. All answers are right.

7. K-file has:

a. Rombous section.
b. Round section.
c. Square section.
d. All answers are right.

8. All of these Ni-Ti rotary systems incorporate:

a. Crown down preparation.
b. Apical preparation as finale.
c. Increasing taper instruments.
d. All answers are right

9. ProTaper System includes:

a. Sx files.
b. F1 files.
c. F2 files.
d. D1 files.

e. D2 files.
f. All answers are right.

10. Shaping files in Pro Taper system are:

a. Sx, S1, S2.
b. F1, F2, F3.
c. D1, D2, D3.
d. All answers are right.

LESSON 13.PREPARATION METHODS OF ROOT CANALS. ROOT CANAL LENGTH DETERMINATION

The questions to be studied for the learning of the topic:

1. Manual preparation techniques for root canal instrumentation
2. Machine technique of root canal instrumentation with ProTaper System
3. Working length determination, definition
4. Methods of working length determination, radiographic method of working length determination
5. Nonradographic methods of working length determination
6. Working length determination with electronic apex locators

Question 1. Manual preparation techniques for root canal instrumentation

Basically, there are two approaches used for biomechanical preparation, either starting at the apex with fine instruments and working up to the orifice with progressively larger instruments, this is Step back technique or starting at the orifice with larger instrument and working up to apex with larger instruments, this is Crown down technique.

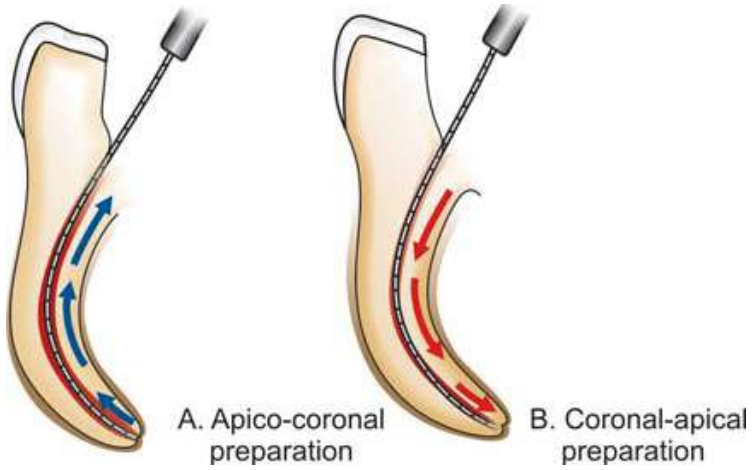


Figure 52. Techniques of root canal preparation

Different other techniques have been modified out of these two basic techniques. Whichever the techniques is used for canal preparation one should ensure of staying within the confines of root canal and resulting in continuous tapered preparation of the canal.

Balanced force technique. This technique, reported by Roane & Sabala in 1985, was originally associated with specially designed stainless-steel or NiTi K-type instruments (Flex-R-Files) with modified tips in a stepdown manner.

This technique is effective with K-type instruments (reamers or files). Instruments are introduced into the root canal with a clockwise motion of maximum 180° and apical advancement (placement phase), followed by a counterclockwise rotation of maximum 120 °with adequate apical pressure (cutting phase). The angle of rotation is usually 30 to 60 degrees. The final removal phase is then performed with a clockwise rotation and withdrawal of the file from the root canal. Apical preparation is recommended to larger sizes than with other manual techniques, e.g., to size #80 in straight canals and #45 in curved canals. The main advantages of the balanced force technique are good apical control of the file tip as the instrument does not cut over the complete length, good centring of the instrument because of the non-cutting safety tip, and no need to pre-curve the instrument.

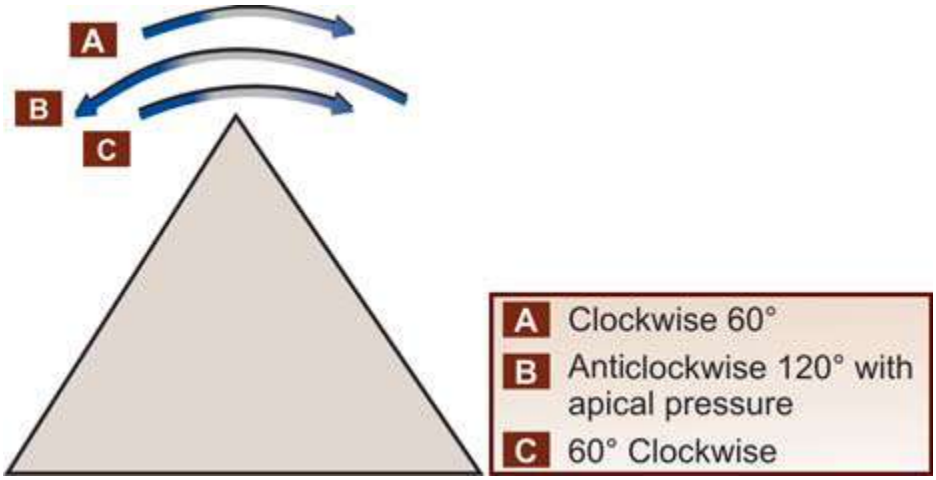


Figure 53. Balanced force technique

Step back technique is also known as Telescopic canal preparation or serial root canal preparation. Step hack technique emphasizes keeping the apical preparation small, in its original position and producing a gradual taper coronally. This technique was first described in I960 by Mullaney.

Basically this technique involves the canal preparation into two phases; phase / involves the preparation of apical constriction and phase II involves the preparation of the remaining canal.

Phase I

7. Initially prepare the access cavity and locate the canal orifices.
8. Establish the working length of the tooth using pathfinder.
9. Now insert the first instrument into the canal with watch winding motion. In watch winding motion, a gentle clockwise and anticlockwise rotation of file with minimal apical pressure is given.
10. Remove the instrument and irrigate the canal.
11. Don't forget to lubricate the instrument for use in apical area because it is shown that lubricant emulsify the fibrous pulp tissue allowing the

instrument to remove it whereas irrigants may not reach the apical area to dissolve the tissues.

12. Place the next larger size file to the working length in similar manner and again irrigate the canal.
13. Don't forget to recapitulate the canal with previous smaller number instrument. This breaks up apical debris which are washed away with the irrigant,
14. Repeat the process until a size 25 K-file reaches the working length. Recapitulate between the files by placing a small file to the working length.

Phase II

1. Place next file in the series to a length 1 mm short of working length. Insert the instrument into the canal with watch winding motion, remove it after circumferential filing, irrigate and recapitulate.
2. Repeat the same procedure with .successively larger files at 1 mm increments from the previously used file.
3. Similarly mid canal area and coronal part of the canal is prepared and shaped with larger number files.
4. Finally refining of the root canal is done by master apical file with push - pull strokes to achieve a smooth taper from of the root canal.

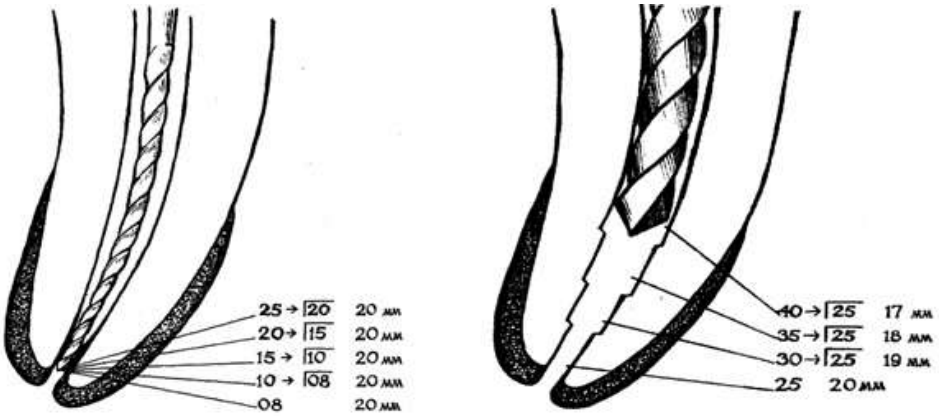


Figure 54. Step back technique

Advantage of Step Back Technique: more flare at coronal part of root canal with proper apical stop.

Disadvantages of Step Back Technique:

1. Difficult to irrigate apical region
2. More chances of pushing debris periapically.
3. Time consuming.
4. Increased chances of iatrogenic errors for example ledge formation in curved canals.
5. Difficult to penetrate instruments in canal.

6. More chances of instrument fracture.

Crown down technique. In the crown down technique, the dentist prepares the canal from crown of the tooth, shaping the canal as he/she move towards the apical portion of the canal. Morgan and Montgomery found that this “crown down pressureless" techniques resulted in a «Hinder canal shape when compared to usual step back technique. Moreover many studies have shown that greater apical enlargement without causing apical transportation can he achieved if coronal obstruction are eliminated.

Technique of Crown Down preparation

1. First step in the crown down technique is the access cavity preparation with no pulp chamber obstructions, Locate the canal orifices with sharp explorer which shows binding in the pulp chamber.
2. Now fill the access cavity with an irrigant and start preflaring of the canal orifices. Preflaring of the coronal third of the canal can be done by using hand instruments. Gates-Glidden drills or the Nickel -titanium rotary instruments.
3. Gates-Glidden drills can be used after scouting the canal orifices with number 10 or 15 files. The crown down approach begins with larger Gates-Glidden first. After using this subsequent, smaller diameter Gates-Glidden arc worked into the canal with additional mm to complete coronal flaring. One should take care to avoid carrying all the Gates-GIidden drills to same level which may lead to excessive cutting of the dentin, weakening of the mots and thereby “Coke Bottle Appearance" in the radiographs.
4. Frequent irrigation with sodium hypochlorite and recapitulation with a smaller file (usually No. 10 file) to prevent canal blockage.
5. After establishing coronal and mid root enlargement explore the canal and establish the working length with small instruments.
6. 6 Introduce larger files to coronal pan of the canal and prepare it. Subsequently introduce progressively smaller number files deeper into the canal in sequential order and prepare the apical part of the canal.
7. Final apical preparation is prepared and finished along with frequent irrigation of the canal system.

The classical apical third preparation should have a tapered shape which has been enlarged to at least size 20 at apex and each successive instrument should move away from the foramen by 1/2 mm increments.

Biological advantages of Crown Down Technique:

1. Removal of tissue debris coronally, thus minimizing the extrusion of debris periapically.
2. Reduction of postoperative sensitivity which could result from periapical extrusion of debris.

3. Greater volumes of irrigants can reach irregularities in the canal in early stages of canal preparation because of coronal flaring.
4. Better dissolution of tissue with increased penetration of the irrigants.
5. Rapid removal of contaminated and infected tissues from the root canal system.

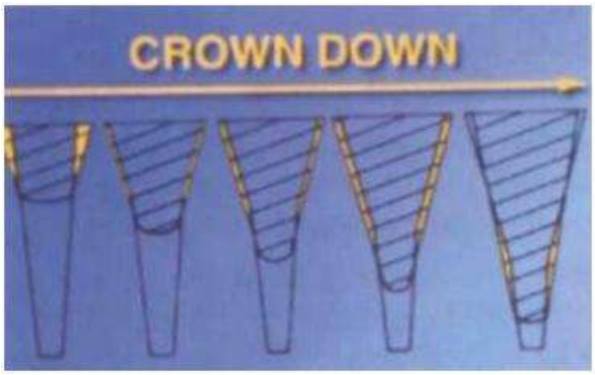


Figure 55. Scheme of Crown Down technique

Clinical Advantages of the Crown Down Technique

1. Enhanced tactile sensation with instruments because of coronal interferences removal.

2. Flexible (smaller) files are used in apical portion of the canal; whereas larger (stiffer) files need not be forced but kept short of the apex.

3. In curved canals, after doing coronal flaring, files can go up to the apex more effectively due to decreased deviation of instruments in the canal curvature.

4. Provides more space for irrigants.

5. Straight line access to root curves and canal junctions.

6. Enhanced movement of debris coronally.

7. Desired shape of canal can be obtained that is narrow at apex, wider coronally.

8. Predictable quality of canal cleaning and shaping.

9. Decreased frequency of canal blockages.

The crown down is often suggested as a basic approach using nickel-titanium rotary instruments.

Question 2. Machine technique of root canal instrumentation with ProTaper System

ProTaper files have a triangular cross-section and are variably tapered across their cutting length. The progressively tapered design improves flexibility, cutting efficiency and the safety of these files. The ProTaper system consists of three shaping and three finishing files. 1. Shaping files are termed as Sx, S1 and S2.

- Sx these are files of shorter length of 19 mm with D1 diameter of 0.19 mm and D14 diameter of 1.20 mm. The increase of taper up to D9 and then taper decrease up to D14 increases its flexibility.

- S1 has D1 diameter of 0.17 mm and D14 of 1.20 mm; it is used to prepare coronal part of the root.

-S2 has D1 diameter of 0.20 mm and D14 of 1.20 mm; it is used to prepare middle third of the canal.

2. Finishing files F1, F2, F3 are used to prepare and finish apical part of the root canal.

F1 D1 diameter and apical taper is 20 and 0.07.

F2 D1 diameter and taper is 25 and 0.08.

F3 D1 diameter and taper is 30 and 0.09.

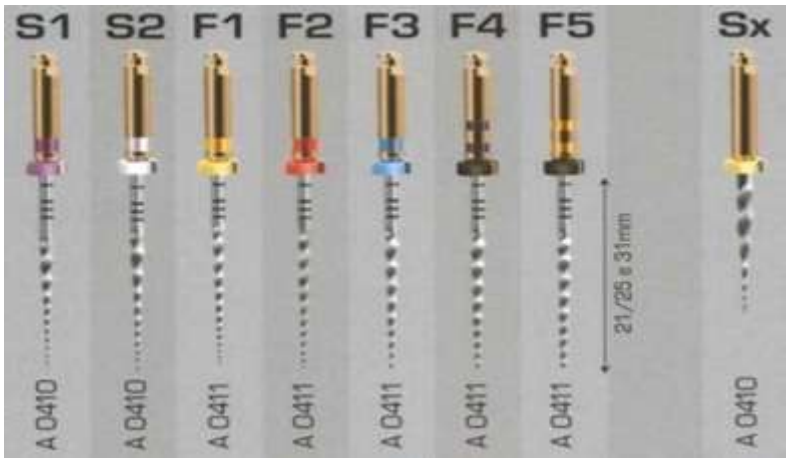


Figure 56. ProTaper Files System

Clinical technique

1. The foremost step is gaining straight line access to the canal orifices.

2. Establish a smooth glide path before doing any instrumentation with ProTaper system,

3. Now prepare the coronal third of the canal by inserting S1 into the canal using passive pressure. Don't go more than third fourth of the estimated canal length.

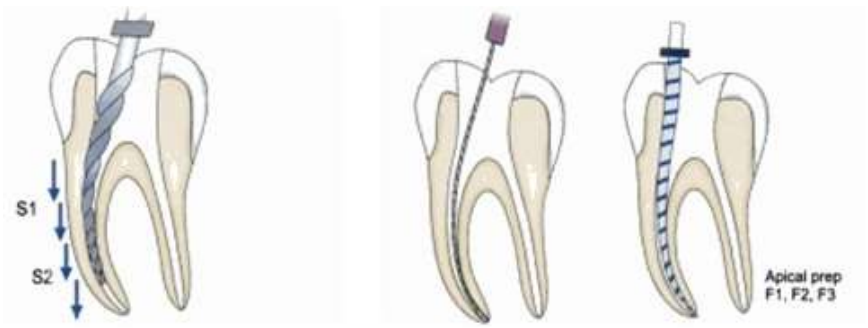


Figure 57. Technique of ProTaper using

4. Irrigate and recapitulate the canal using number 10 file.

5. In shorter teeth, use of Sx is recommended

6. After this S2 is worked up to the estimated canal length.

7. Now confirm the working length using small stainless steel K-files up to size 15 by electronic apex locators and/or with radiographic confirmation.

8. Use F1, F2, and F3 (if necessary) finishing files up to established working length and complete the apical preparation. Then refine the apical preparation using corresponding stainless steel file to gauge the apical foramen and to smoothen the canal walls.

Advantages of ProTaper Files:

1. ProTaper file has modified guiding tip which allows one to follow canal better and variable tip diameters allow file to have specific culling action in defines area of canal without stressing instrument in other sections.
2. ProTaper file has a changing helical angle and pitch over their cutting blades which reduces the instrument from screwing into the canal and allows better removal of debris.
3. ProTaper file acts in active motion, this further increases its efficiency and reduces torsional strain.
4. Length of file handle is reduced from 15 to 12.5 mm which allows belter access in posterior areas.

Question 3. Working length determination, definition

According to endodontic glossary working length is defined as the distance from a coronal reference point to a point at which canal preparation and obturation should terminate.

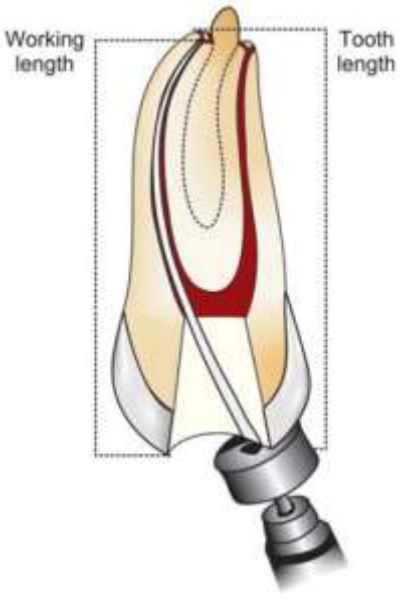


Figure 58. Working length

Reference point. Reference point is that site on occlusal or the incisal surface from which measurements are made. A reference point is chosen which stable and easily visualized during preparation. Usually this is the highest point on incisal edge of anterior teeth and buccal cusp of posterior teeth. Reference point should not change between the appointments. For example in case of teeth with undermined cusps and fillings, they should be reduced considerably before access preparation. Anatomic apex is tip or end of root determined morphologically.

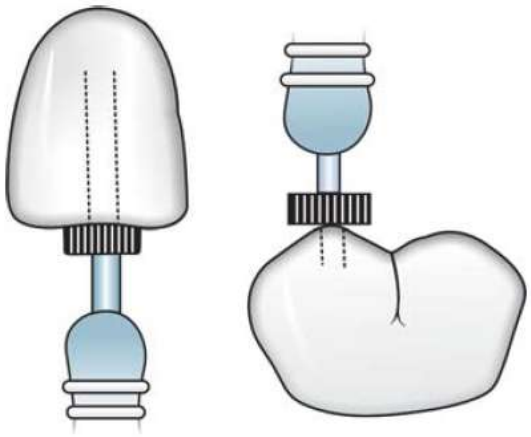


Figure 59. Reference point

Radiographic apex is tip or end of root determined radio graphically.

Apical foramen is main apical opening of the root canal which may be located away from anatomic or radiographic apex.

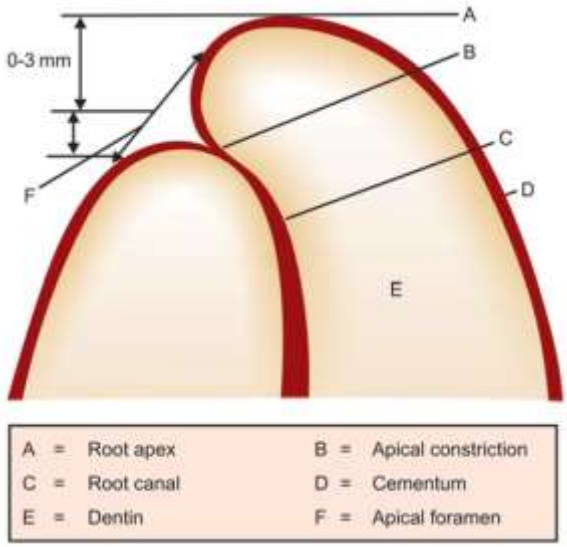


Figure 60. Anatomy of root apex

Apical constriction (minor apical diameter) is apical portion of root canal having narrowest diameter. Ii is usually 0.5 - 1 mm short of apical foramen. The minor diameter widens apically to foramen i.e. major diameter.

The cementodentinal junction is the region where cementum and dentin are united, the point at which cemental surface terminates at or near the apex of tooth. It is not always necessary that CDJ always coincide with apical constriction, luxation of CDJ ranges from 0.5 - 3 mm short of anatomic apex.

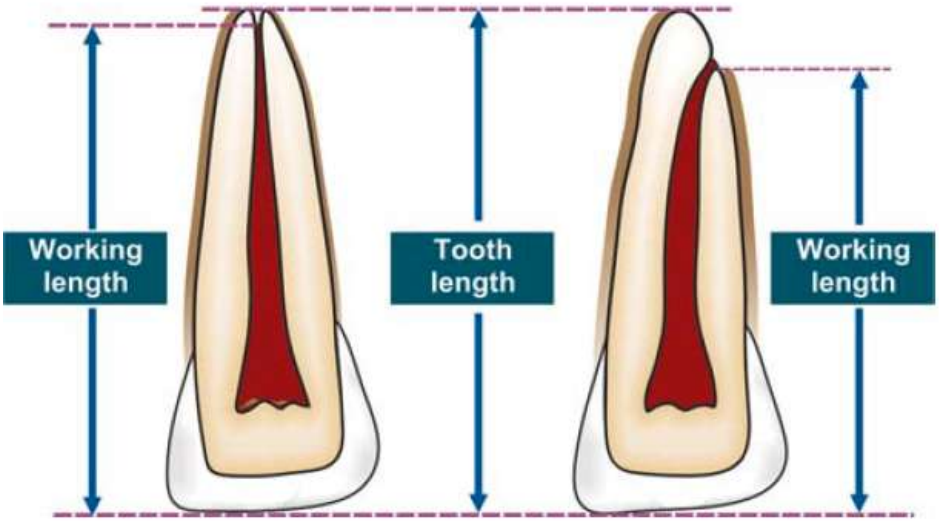


Figure 61. Variation in location of CDJ

Significance of working length

- Working length determines how far into canal, instruments can be placed and worked.
- It affects degree of pain and discomfort which patient will experience following appointment by virtue of over and under instrumentation.
- If placed in correct limits, it plays an important role in determining the success of treatment.
- Before determining a definite working length, there should be straight line access for the canal orifice for unobstructed penetration of instrument into apical constriction.
- Once apical stop is calculated, monitor the wotting length periodically because working length may change as curved canal is straightened.
- Failure to accurately determine and maintaining working length may result in length being over than normal which will lead to postoperative pain, prolonged healing time and lower success rate because of incomplete regeneration of cementum. Periodontal ligament and alveolar bone.
- When working length is made short of apical constriction it may cause persistent discomfort because of incomplete cleaning and underfilling.

Apical leakage may occur into uncleaned and unfilled space short of apical constriction. It may support continued existence of viable bacteria and contributes to the periradicular lesion and thus poor success rate.

Question 4. Methods of working length determination, radiographic method of working length determination

Different methods for determining working length include using average root lengths from anatomic studies, preoperative radiographs, tactile sensation, etc. Other common methods include use of paper point, working length radiograph, electronic apex locators or any combination of the above.

In this era of improved illumination and magnification, working length determination should be to the nearest 1.5 mm. So to achieve the highest degree of accuracy a combination of several methods should be used.

Various Methods of Determining Working Length

- Average root length from anatomic studies
- Radiographs
- Mathematics method
- Tactile sensation
- Bleeding on paper point
- Apical periodontal sensitivity
- Electronic apex locator

Radiographic method of working length determination

Radiographic apex has been used as termination point in working length determination since many years; and it has showed promising results. But there are two schools of thoughts regarding this:

Those who follow this concept say cementodentinal junction is impossible to locate clinically and the radiographic apex is the only reproducible site available for length determination. According to it, a patent root tip and larger files kept within the tooth may result in excellent prognosis.

Those who don't follow this concept say that position of radiographic apex is not reproducible. Its position depends on number of factors like angulation of tooth, position of film, film holder, length of X-ray cone and presence of adjacent anatomic structures etc.

When radiographs are used in determining working length the quality of the image is important for accurate interpretations.

Among the two commonly used techniques, paralleling techniques have been demonstrated as superior to bisecting angle technique in determination and reproduction of apical anatomy.

As the angle increases away from parallel, the quality of image decreases. This occurs because as the angle as increased, the tissue that X-

rays must pass through include a greater percentage of bone mass and root anatomy becomes less apparent.

Parallel working length radiographs can be difficult to attain because of disorientation, shallow palatal vault and tori etc. But good film holders like Endo Ray II film holder may help in improving the results.

Before studying the X-rays for endodontics, understanding of buccal object role is essential. The basic concept of the rule is that as the vertical or horizontal angulation of X-ray tube changes, the object buccal or closest to lube head moves to opposite side of radiograph compared to the lingual object.

To separate buccal and lingual roots (for example in maxillary first premolar) to visualize the working length, tube head should be moved from a 200 mesial angulation. This captures the buccal root to the opposite or distal side of radiograph and lingual root on mesial side of the radiograph. It is also known as SLOB rule that is same lingual opposite buccal. Although the individual canals can usually be distinguished by applying the SLOB rule and knowing the angle at which the radiographs was made, misinterpretation is still possible. This can be reduced by using different types of files like K and H-files or different file sizes in different canals.

Radiographic method of length determination involves measurement of radiographic apex and then subtracting a specific value from that length.

Before access opening, fractured cusps, cusps weakened by caries or restorations arc reduced to avoid fracture of weakened enamel during the treatment. This will avoid the loss of initial reference point and thus the working length. In this method, preoperative periapical radiograph is used to calculate the working length for endodontic treatment.

OrthoPantograph (OPG) radiographs are not advocated for calculating tentative working length because of gross magnification of 13-28 percent employed in OPG which will load to errors in calculation of accurate readings.

This measurement is used as estimated working length which can then be confirmed by placing an endodontic instrument into (he canal and taking a second radiograph.

The instrument inserted in the canal should he large enough not to be loose in the canal as it will move while taking the radiograph and thus may cause errors in determining the working length.

Fine instruments are often difficult to see in their entirely in a radiograph. The new working length is calculated by adding or subtracting the distance between the instrument tip and desired apical termination of the root.

The correct working length is finally calculated by-subtracting I mm as safety factor from this new length. This technique wax first introduced by John Ingle. Weine modified this subtraction rule as follows:

a. If radiograph shows absence of any resorption i.e. bone or root apex, shorten the length by 1 mm.

b. If periapical bone resorption is present, shorten it by 1.5 mm.

c. If both bone and root resorption is seen, shorten it by 2 mm. This is done because if there is root resorption, loss of apical constriction may occur in such cases. In curved canals, canal length is reconfirmed because final working length may shorten up to I mm as canal Is straightened out by instrumentation. If root contains two canals, the cone should be positioned at a 20 to 30 degree horizontal deviation from the standard facial projection.

Radiographic Method of Length Determination

1. Measure the estimated working length from preoperative periapical radiograph.
2. Adjust stopper of instrument to this estimated working length and place it in the canal up to the adjusted stopper
3. Take the radiograph.
4. On the radiograph measure the difference between the of the instrument and root apex. Add or subtract the length to the estimated working length to get the new working length.
5. Correct working length is finally calculated by subtracting 1 mm from this now length.

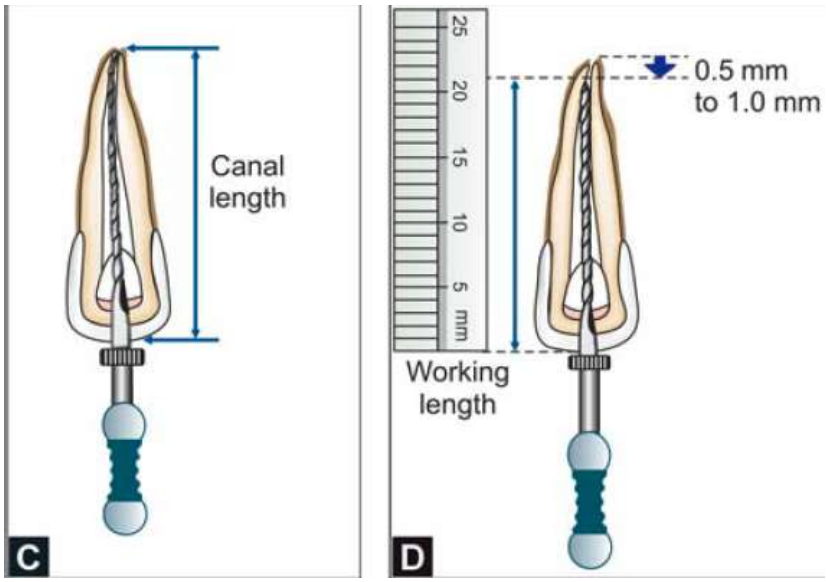


Figure 62. Radiographic Method of Length Determination

Modification in the Length Subtraction

1. No resorption - subtract 1 mm
2. Periapical bone resorption - subtract 1.5 mm

3. Periapical bone + root apex resorption - subtract 2 mm.

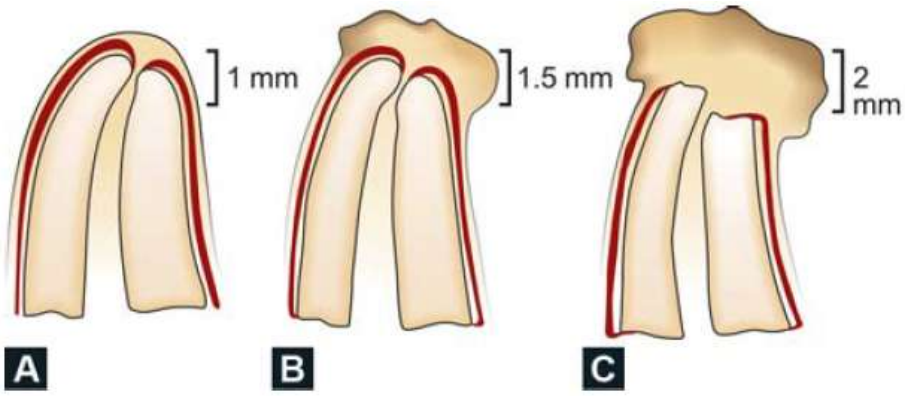


Figure 63. Modification in the Length Subtraction

Question 5. Nonradographic methods of working length determination

Mathematic method of working length determination. It is based on simple mathematical formulations to calculate the working length. In this, an instrument is inserted into the canal, stopper is fixed to the reference point and radiograph is taken. The formula to calculate actual length of the tooth is as follows:

$$\frac{\textit{Actual length of the tooth}}{\textit{Actual length of instrument}} = \frac{\textit{Apparent length of tooth in radiograph}}{\textit{Apparent length of instrument in radiograph}}$$

By above, as we see those three variables are known and by applying the formula, 4th variable i.e. actual length of tooth can be calculated.

$$\textit{Actual length of tooth} = \frac{\textit{Actual length of the instrument} \times \textit{Apparent length of tooth in radiograph}}{\textit{Apparent length of instrument on radiograph}}$$

Disadvantages

- Wrong readings can occur because of:
- Variations in angles of radiograph
- Curved roots
- S-shaped, double curvature roots

Other methods of working length determination include employing tactile sense by instrument, apical-periodontal sensitivity and using paper point measurement etc.

Digital tactile sense: in this method the clinician may see an increase in resistance as file reaches the apical 2-3 mm.

Advantages: time saving; no radiation exposure.

Disadvantages: does not always provide the accurate readings in case of narrow canals, one may feel increased resistance as file approaches apical 2–3 mm in case of teeth with immature apex, instrument can go periapically.

Periodontal sensitivity test: this method is based on the patient's response to pain. But this method does not always provide accurate readings; for example, in case of narrow canals, instrument may feel increased resistance as file approaches apical 2–3 mm; in case of teeth with immature apex, instrument can go beyond apex. In cases of canal with necrotic pulp, instrument can pass beyond apical constriction; in case of vital or inflamed pulp, pain may occur several mm be- fore periapex is crossed by the instrument.

Paper point measurement method: in this method, paper point is gently passed in the root canal to estimate the working length. It is most reliable in cases of open apex where apical constriction is lost because of perforation or resorption. Moisture or blood present on apical part of paper point indicates that paper point has passed beyond estimated working length.

But all these methods don't always provide the accurate readings, for example in case of narrow canals, instrument may feel increased resistance as file approaches apical 2-3 mm and in case of teeth with immature apex instrument can go beyond apex. Similarly while performing apical periodontal sensitivity test in eases of canal with necrotic pulp, instrument can pass beyond apical constriction and in case of vital or inflamed pulp, pain may occur several mm before periapex is crossed by the instrument. These methods should not be used alone for determining working length they should be used as supplement to radiographs apex locators etc.

Question 6. Working length determination with electronic apex locators

Radiographs arc often misinterpreted because of difficulty in distinguishing the radicular anatomy and pathology from normal structures. Electronic apex locators (EAL) are used for determining working length as an adjunct to radiography. They are basically used to locate the apical constriction or cementodentinal junction or the apical foramen, and not the radiographic apex. Hence the term apex locator is a misnomer one.

The ability to distinguish between minor diameter and major diameter of apical terminus is most important for the creation of apical control zone. The apical control zone is the mechanical alteration of the apical terminus of root canal space which provides resistance and retention form to the obturating material against the condensation pressure of obturation. Various

studies have shown that electronic apex locators have provided more accurate results when compared to conventional radiographs.

Uses of Apex Locators

1. They provide objective information with high degree of accuracy.
2. They are useful in conditions where apical portion of canal system is obstructed by:
    a. Impacted teeth
    b. Zygomatic arch
    c. Tori
    d. Excessive bone density
    e. Overlapping roots
    f. Shallow palatal vault.

    In such cases, they can provide information which radiographs cannot.
3. They are useful in patient who cannot tolerate X-ray film placement because of gag reflex.
4. In case of pregnant patients, to reduce the radiation exposure, they can be valuable tool.
5. They can also be used in children who may not tolerate taking radiographs, disabled patients and patients who are heavily sedated.
6. They are valuable tool for:
    a. Detecting site of root perforations
    b. Diagnosis of external and internal resorption which have penetrated root surfaces.
    c. Detection of horizontal and vertical root fracture
    d. Determination of perforations caused during post preparation
    e. Testing pulp vitality

    They are helpful in root canal treatment of teeth with incomplete root formation, requiring apexification and to determine working length in primary teeth.

Contraindications to the Use of Apex. Apex locators are contraindicaied in the patients who have cardiac pacemaker functions. Electrical stimulation to such patients can interfere with pace maker function.

It has been shown that in teeth with periapical radiolucencies, and necrotic pulps associated with root resorption etc. the use of apex locators is not much beneficial. In such cases there is alteration of apical constriction and lack of viable periodontal ligament tissue to respond to EAL which may cause abnormally long readings.

Advantages of Apex Locators:

1. Provide objective information with high degree of accuracy.
2. Accurate in reading (90–98 % accuracy)
3. Some apex locators are also available in combination with pulp tester, so they can be used to test pulp vitality.

Disadvantages:

a. Can provide inaccurate readings in the following cases: presence of pulp tissue in canal too wet or too dry canal use of narrow file blockage of canal incomplete circuit low battery
b. Chances of overestimation
c. May pose problem in teeth with immature apex.

Basic Conditions for Accuracy of EALs. Whatever is the generation of apex locator, there are some basic conditions, which ensure accuracy of their usage.

1. Canal should be free from most of the tissue and debris.
2. The apex locator works best in a relatively dry environment. But extremely dry canals may result in low readings i.e. long working length.
3. Cervical leakage must be eliminated and excess fluid must be removed from the chamber as this may cause inaccurate readings.
4. If residual fluid is present in the canal, it should be of low conductivity value, so that it does not interfere the functioning of apex locator.
5. Since EALs work on the basis of contact with canal walls and periapex, the better the adaptation of file to the canal walls, the more accurate as the reading.
6. Canals should be free from any type of blockage, calcifications etc.
7. Battery of apex locator and other connections should be proper.

Tests to the topic

1. The basic techniques of manual preparation for root canal instrumentation are:

a. Balanced force technique.
b. Step back technique.
c. Crown down technique.
d. All answers are right.

2. Shaping files in pro taper system are:

a. Sx, s1, s2.
b. F1, f2, f3.
c. D1, d2, d3.
d. All answers are right.

3. Finishing files are:

a. Sx, s1, s2.
b. F1, f2, f3
c. D1, d2, d3.
d. All answers are right.

4. What is radiographic apex?

a. It is tip or end of root determined radio graphically.
b. It is main apical opening of the root canal which may be located away from anatomic or radiographic apex.
c. It is apical portion of root canal having narrowest diameter.
d. All answers are right.

5. What is apical foramen?

a. It is tip or end of root determined radio graphically.
b. It is main apical opening of the root canal which may be located away from anatomic or radiographic apex.
c. It is apical portion of root canal having narrowest diameter.
d. All answers are right.

6. What is apical constriction?

a. It is tip or end of root determined radio graphically.
b. It is main apical opening of the root canal which may be located away from anatomic or radiographic apex.
c. It is apical portion of root canal having narrowest diameter.
d. All answers are right.

7. What are the methods of working length determining?

a. Average root length from anatomic studies.
b. Radiographs.
c. Mathematics method.
d. Electronic apex locator.
e. All answers are right.

8. What are the indications of apex locator using?

a. In the patients who have cardiac pacemaker functions.
b. For testing pulp vitality.
c. In patients who cannot tolerate x-ray film placement because of gag reflex.
d. In case of pregnant patients, to reduce the radiation exposure, they can be valuable tool.
e. All answers are right.

9. What are the contraindications of apex locator using?

a. In the patients who have cardiac pacemaker functions.
b. For testing pulp vitality.
c. In patients who cannot tolerate x-ray film placement because of gag reflex.

d. In case of pregnant patients, to reduce the radiation exposure, they can be valuable tool.
e. All answers are right.

10. What are the advantages of apex locators?

a. Provide objective information with high degree of accuracy.
b. Accurate in reading (90–98 % accuracy).
c. May pose problem in teeth with immature apex.
d. All answers are right.

LESSON 14. ROOT CANAL SYSTEM IRRIGATION AND INTRACANAL MEDICAMENTS

The questions to be studied for the learning of the topic:

1. Irrigation of root canal system, requirements to irrigants
2. Commonly used irrigating solutions
3. Chelating agents
4. Newer methods of root canal irrigation
5. Method of root canal system irrigation
6. Intracanal medicaments

Question 1. Irrigation of root canal system, requirements to irrigants

During the past years, endodontics has begun to appreciate critically the important role of irrigation in successful endodontic treatment. The objective of endodontic treatment is to prevent or eliminate infection within the root canal. Over the years, research and clinical practices have concentrated on instrumentation, irrigation and medication of root canal system followed by obturation and the placement of coronal seal. It's truly said. "Instruments shape, irrigants clean". Every root canal system has spaces that cannot be cleaned mechanically. The only way we can clean webs, fins and anastomoses is through the effective use of an irrigation solution. In order to get maximum efficiency from the irrigant, irrigant must reach the apical portion of the canal. Irrigation is an important part of root canal treatment because it assists in (a) removing bacteria and debris (b) configuring the system so that it can be obturated to eliminate dead space. It has been found that use of saline as an irrigant before and after instrumentation, markedly resulted in a 100 to 1000 fold reduction in bacterial counts.

An ideal irrigant solution must fulfill the following criteria:

1. It must have broadspectrum antimicrobial properties.
2. It must aid in the debridement of the canal system.
3. It should have the ability to dissolve necrotic tissue or debris.
4. It should have low toxicity level.
5. It should be a good lubricant
6. It should have low surface tension so that it can easily flow into inaccessible areas.
7. It should be able to effectively sterilize the root canal (or at least disinfect them).
8. It should be able to prevent formation of smear layer during instrumentation or dissolve the latter once it is formed.
9. It should inactivate endotoxin.

Other desirable properties of ideal irrigants include availability, cost, ease of use, convenience, adequate shelf life and ease of storage. In addition

to these properties, if endodontic irrigants come in contact with vital tissue, these should be systemically nontoxic, noncaustic to the periodontal tissue and have little potential to cause an anaphylactic reaction.

Functions of irrigants:

1. Irrigants perform physical and biologic functions. Dentin shavings get removed from canals by irrigation. Thus, they do not get packed at the apex of root canal.
2. Instruments do not work properly in dry canals. Their efficiency increases by use in wet canals. Instruments are less likely to break when canal walls are lubricated with irrigation.
3. Irrigants act as solvent of necrotic tissue, so they loosen debris, pulp tissue and microorganisms from irregular dentinal walls.
4. Irrigants help in removing the debris from accessory and lateral canals where instruments cannot reach.
5. Most irrigants are germicidal hut they also have antibacterial action.
6. Irrigants also have bleaching action to lighten teeth discolored by trauma or extensive silver restorations.
7. Though prescnce of irrigants in canal facilitate instrumentation but simultaneous use of some lubricating agents (RC prep, REDTAC, Glyde, etc.) make the instrumentation easier and smoother.

Currently, there is no single irrigant that can fulfill all of these criteria and so we have to rely on different irrigating solutions and sometimes their combination. The main irrigants include sodium hypochlorite, chlorhextdine and ethylene diamine tclraacetic acid. Unfortunately, this does not seem to be one clear regimen that should he followed to maximize the benefits of each of these materials.

Question 2. Commonly used irrigating solutions

Chemically non-active solution

- Water
- Saline
- Local anesthetic

Chemically active materials

- Alkalis: Sodum hypochlorite 0.5-5.25%
- Chelating agents: ethylene diamine tetra acetic acid (EDTA)
- Oxidizing agents: hydrogen peroxide, carbamide peroxide
- Antibacterial agents: chlorhexidine
- Acids: 30% hydrochloic acid
- Enzymes: streptokinase, papain, trypsin
- Detergents: sodium laruyl sulphate Sodium Hypochlorite

Sodium hypochlorite. Sodium hypochlorite is a clear, pale, green-yellow liquid with strong odor of chlorine. It is easily miscible with water and gets decomposed by light. Mechanism of Action of Sodium Hypochlorite

Sodium hypochlorite contains 5 percent of free chlorine which is important for breakdown of proteins into amino groups, At body temperature, reactive chlorine in aqueous solution exists in two forms-hypochlorite (OCI^-) and hypochlorous acid (HOCI). State of available chlorine depends on pH of solution, i.e. above pH of 7.6, mainly hypochlorite form and below this hypochlorous acid.

The pH of commonly used sodium hypochlorite is 12, at which the OCI form exits. But as we have seen that hypochlorous acid is more bactericidal, so to increase the efficacy of NaOCI solution. I percent sodium bicarbonate is added us buffering agent. Buffering makes the solution unstable, thus decreases its shelf life to even less than one week. Buffered and diluted sodium hypochlorite should be stored in dark and cool place.

Methods by which we can increase the efficacy of sodium hypochloride are:

1. *Time*: since antimicrobial effectiveness of sodium hypochlorite is directly related to its contact time with the canal, greater the contact time, more effective it is. This is especially important in necrotic cases.
2. *Heat*: it has been shown that warming sodium hypochlorite to $60\text{-}70^0$ increases its solvent properties and tissue dissolving properties. But one should be careful not to overheat the solution because this can cause breakdown of sodium hypochlorite constituents and thus may damage the solution.
3. *Specialized irrigating syringes*: most researches have shown that unaided irrigation requires at least a size № 25 apex for it to reach tl»e more apical portions of canals Newer specialized side venting endodontic syringes with narrower diameter (32 gauge) arc available which aid in getting irrigant closer to apex and help the imgant to move sideways.
4. *Ultrasonic activation* of sodium hypochlorite has also shown to accelerate chemical reaction, create cavitational effect and thus achieve a superior cleansing action. But it is seen that if ultrasonic activation of sodium hypochlorite is used, it is better to apply ultrasonic instrument after canal preparation. A freely oscillating instrument causes better effect than the instrument which binds to canal walls.

Also the ultrasonic files cause more uncontrolled cutting of canal walls especially if used during preparation. Thus use of a noncutting instrument after canal preparation is best option for optimal effects.

Precautions to be taken while using sodium hypochlorite solution. It is important to remember that though sodium hypochlorite is nontoxic during

intracanal use but 5.25 percent NaOCl can cause serious damage to tissue if injected periapically.

If sodium hypochlorite gets extruded into periapical tissues, it causes excruciating pain, periapical Weeding and swelling, As potential for spread of infection is reluted to tissue destruction, medication like antibiotics, analgesics, antihistamine should be prescribed accordingly. In addition to these, reassurance to the patient is the prime consideration. Thus irrigation with sodium hypochlorite solution should always be performed passively especially in cases with larger apical diameters and needles with very small diameter, also the syringe should never be locked in the canal.

Use of Sodium Hypochlorite in Combination with other Medicaments

Many studies have shown that efficacy of sodium hypochlorite as antimicrobial agent is increased when it is used in combination with other solutions such as calcium hydroxide, EDTA or chlorhexidine.

The tissue dissolving capacity of sodium hypochlorite or chlorhexidine is found to be increased when tissue is pretreated with calcium hydroxide.

Wadachi et al. in their study have shown that combination of calcium hydroxide and sodium hypochlorite was better than either of medicament alone. Various studies have shown that combination of sodium hypochlorite and EDTA has more bactericidal effect which is probably due to removal of contaminated smear layer by EDTA.

Hydrogen peroxide is clear, odorless liquid. It is mainly the 3 percent solution which is used as an irrigating agent.

Mechanism of Action

- ✓ It is highly unstable and easily decomposed by heat and light. It rapidly dissociates into water and nascent oxygen. On coming in contact with tissue enzymes catalase and peroxidase, the liberated produces bactericidal effect but this effect is transient and diminishes in presence of organic debris.
- ✓ It causes oxidation of bacterial sulfhydryl group of enzymes and thus interferes with bacterial metabolism.
- ✓ The rapid release of [O] nascent oxygen on contact with organic tissue results in ellervescence or bubbling action which is thought to aid in mechanical debridement by dislodging particles of necrotic tissue and dentinal debris and floating them to the surface.

Uses. It is used as an irrigating solution either alone or alternatively with sodium hypochlorite. The advantage of using alternating solutions of 3% H202 and 5.2% NaOCl are:

- ✓ Effervescent reaction by hydrogen peroxide bubbles pushes debris mechanically uul of root canal.
- ✓ Solvent action of sodium hypochlorite on organic debris.
- ✓ Disinfecting and bleaching action by both solutions.

Clinical Tips. While using combination of sodium hypochlorite and hydrogen peroxide, always use sodium hypochlorite in the last because hydrogen peroxide can react with pulp debris and blood to produce gas (nascent oxygen) which builds up pressure on closing the tooth, this can result in severe pain.

Chlorhexidine

- Chlorhexidine is the most potent of the tested bisbiguanides.
- It has strong base and is most stable in the form of its salts, i.e. chlorhexidine gluconate.
- It has a potent antiseptic which is widely used for chemical plaque control in the oral cavity in concentrations of 0.2%.
- It shows optimal antimicrobial action between pH 5.5 and 7.0
- For using it as an irrigant. it should be used as 2% in concentration.

Combination of 0.2% clorhexidine and 2% sodium hypochlorite. This combination is commonly used as irrigant in root canals because

- Chlorhexidine being a base forms salts of organic acids where as sodium hypochlorite being an oxidizing agent, oxidizing gluconate part of chlorhexidine gluconate and forms gluconic acid
- There is an increase in ionizing capacity of chlorgexidme due to formation of chlorhexidine Cl (Cl group get attached to guanidine part of chlorhexidine)
- Combination of chlorhexidine IpH 6.5) and sodium hypochlorite (pH 9- 10) is more alkaline (pH 10) making it more effective
- Chlorhexidine PLUS: Detergent has been added to sodium hypochlorite which increases the speed dissolution by NaOCl

Mechanisms of Action

- ✓ Chlorhexidine is broadspectrum antimicrobial agent.
- ✓ The antibacterial mechanism of chlorhexidine is related to its cationic bisbiguanide molecular structure.
- ✓ The cationic molecule is absorbed to the negatively charged inner cell membrane and causes leakage of intracellular components.
- ✓ At low concentration, it acts as a bacteriostatic, whereas at higher concentrations; it causes coagulation and precipitation of cytoplasm and therelore acts as bactericidal.
- ✓ It is more effective against E. Faecalis as compared to NaOCI.
- ✓ In addition, chlorhexidine has the property of substantivity (residual effect). Both 2 and 0.2 percent chlorhexidine can cause residual antimicrobial activity for 72 hours or even up to 7 days it used as an endodontic irrigant.

Advantages and Uses

1. A 2% solution it used as root irrigant in canals.
2. A 0-2% solution can be used in controlling plaque activity.

3. It is more effective on gram-positive bacteria than gram-negatrvc bacteria.
4. Used in combination with Ca(OH)2, as intracanal medicament in necrotic teeth and retreatment cases.

Disadvantages

1. It is not considered as the main irrigant in standard endodontic therapy.
2. It is unable to dissolve necrotic tissue remnants.
3. It is less effective on gram-negatrve than on gram-positive bacteria.
4. Does not show effect on biofilms.

Table 23. **Summary of irrigants used during endodontic therapy**

Irrigant	***NormaI saline***	***Sodium hypochlorite***	***Hydrogen peroxide***	***EDTA***	***Chlorhexidine***
Concentration	0.9%	1%, 2.5%, 5.25%	3%	15%, 17%	0.12%, .2%, 2%
pH	7.3	10.8-12	6	7.3-8	5.5-7
Mechanism of action	Physical flushing	Bactericidal	Bactericidal 1. Dissociates in H90 and [O][O] has bactericidal activity 2. ii.Causes oxidation of sulfhydryl groups of enzymes 3. iii.Effervescent reaction of H_2O_2 bubbles causes mechanical debridement	1. Lubrication, emulsification and holding debris in suspension 2. Forms chelate with calcium ions of dentin making it more friable and easier to manipulate	1. At lowconcentration bacteriostatic 2. At high concentration bactericidal by causing coagulation and precipitation of cytoplasm
Advantages	No side effects if extruded periapically	Has dissolution, disinfectant and antimicrobial properties	Has disinfectant and antimicrobial property	Dentin dissolving property	1. Property ofsubstantivity 2. More effective against gram-positive bacteria

Disadvantages	Too mild to be disinfectant	Can cause tissue injury if extruded periapically		Makes easier manipulation of canals	1. Unable to dissolve necrotic tissue remanants 2. Less effective on gram-positive bacteria

Question 3. Chelating agents

After canals are instrumented. an organic layer remains which covers the dentinal tubules. Controversies still exist whether to keep or to remove smear layer as it relates to permeability of dentin. However, most of studies have recommended removal of smear layer bccause it is the source of microorganisms and also the closest possible adaptation ol endodontic filling is possible only alter its removal.

Though sodium hypochlorite is thought to be almost ideal irrigating solution but it does not possess chelating properties. EDTA and other chelating agents like citric acid, polyacrilic acids are used for this purpose.

Chelating agent is defined as a chemical which combines with a metal to form chelate.

EDTA is most commonly used chelating agent. It was introduced in dentistry by Nygaard-Ostby for cleaning and shaping of the canals. It contains four aceticacid groups attached to ethylenediamine. EDTA is relatively nontoxic and slightly irritating in weak solutions. The effect of EDTA on dentin depends on the concentration of EDTA solution and length of time, it is in contact with dentin. Serper and Call in their study observed that EDTA was more effective at a neutral pH than at a pH 9.0. They showed that for optimal cleaning and shaping of canals EDTA should be used at neutral pH and with lower concentrations.

Clinical Tips

- EDTA and citric acid are used for 2 to 3 minutes at the end of instrumentation to remove the smear layer so as to improve the antibactenal effect of locally used disinfecting agents in deeper layer of dentin.
- EDTA or citric acid should never be mixed with sodium hypochlorite because EDTA and citnc acid strongly interact with sodium hypochlorite. This immediately reduces the available chlorine in solution and thus making it ineffective against bacteria.

Functions of EDTA

- Lubrication

- Emulsiftcatton
- Molding debris in suspension
- Smear layer removal

Mechanism of Action

1. It inhibits growth of bacteria and ultimately destroys them by starvation because EDTA chelates with the metallic ions in medium which are needed lor growth of microorganisms.
2. EDTA has self-limiting action. It forms a stable bond with calcium and dissolves dentin, but when all chelating ions are reacted, an equilibrium is reached which prevents further dissolution. Uses of EDTA
3. It has dentin dissolving properties.
4. It helps in enlarging narrow canals.
5. Makes easier manipulation of instruments.
6. Reduces time needed for debridement.

Different Forms of EDTA

1. R-EDTA: In the EDTA is combined with cetrimide, i.e. cetyltrimethylammonium bromide. It helps in better cleaning of canals.

2. EDTAT (EDTA ♦ Texapon): Here EDTA is combined with sodiumlaurylsulfate which results in decreasing the surface tension.

3. EDTA-C: It is commercially available as 15% solution and pH of 7.3 under the name EDTAC because it contains cetavelon, a quaternary ammonium compound which is added due to its disinfecting properties. Also the addition of surfactant reduces the contact angle of EDTA when placed on dentin surface and thus enhances its cleaning efficacy.

A chelating agent can be applied in liquid or paste form. The use of paste type preparation was first advocated by Stewart who devised a combination of urea peroxide with glycerol. Later this product was modified by combining EDTA, urea peroxide and water soluble carbowax. i.e. polyethylene glycol as vehicle. This product is commercially available as RC Prep. It is an effective lubricating and cleaning agent. Presence of glycol makes it a lubricant and coats the instrument which facilitates its movement in the canal.

A viscous suspension of chelator promotes the emulsilication of organic debris and facilitates negotiation of the canal. Collagen is the major constituent of vital pulp which can be packed into glue like mass which contributes to iatrogenic blocks. Without the use of a chelator, vital tissue tends to collapse and readheres to itself but use of chelator does not allow this phenomenon to occur and accelerate emulsilication ol tissue.

Clinical Tips. Collagen is major constituent of vital pulp which can be packed into glue-like mass which contributes to iatrogenic blocks. Without the use of a chelator, vital tissue tends to collapse and readheres to itself but

use of chelator does not allow this phenomenon to occur and accelerate emulsification of tissue.

Citric Acid

- Citric acid can be used alone or in combination with other irrigants.
- Used for smear layer removal

Polyacrylic Acid. Another chelating agent suggested as irrigant is polyacrylic acid, commercially available as Durelon and Fuji II liquid.

Hydroxyethylidene Bisphosphonate

- It is also known as Etidronate having chelating properties, suggested ax an irrigating solution.
- The advantageous property of hydroxyethylidene bis-phosphonate (HEBP) ax chelating agent ix that it shows only short-term interference with sodium hypochlorite.

Salvizol

- It belongs to surface acting materials like quaternary ammonium group.
- It shows antibacterial property even in presence of organic materials.
- It is most effective against gram-positive and gram-negative microorganisms and fungi.

Question 4. Newer methods of root canal irrigation

Ultrasonic irrigation has shown to clean the root canals or eliminates bacteria from the walls better than conventional methods (hand instrumentation alone).

Use of ultrasonics causes continuous flow of an irrigant in the canal, thus prevents accumulation of debris in the canal

Mechanism of Action. When a small tile is placed in canal and ultrasonic activation is given. The ultrasonic energy passes through irrigating solution and exerts its "acoustic streaming or scrubbing" effect on the canal wall. This mechanical energy warms the irrigant solution (Sodium hypochlorite) and dislodges debris from canal. The combination of activating and heating the irrigating solution is adjunct in cleaning the root canal.

Advantages

- ✓ It cleans the root canal walls better than conventional ones.
- ✓ It removes the smear layer efficiently.
- ✓ It dislodges the debris from the canal better due to acoustic effect.

Disadvantages

- ✓ Ultrasonic preparation of the canal is found to be unpredictable.
- ✓ It can lead to excessive cutting of canal walls and may damage the finished preparation.

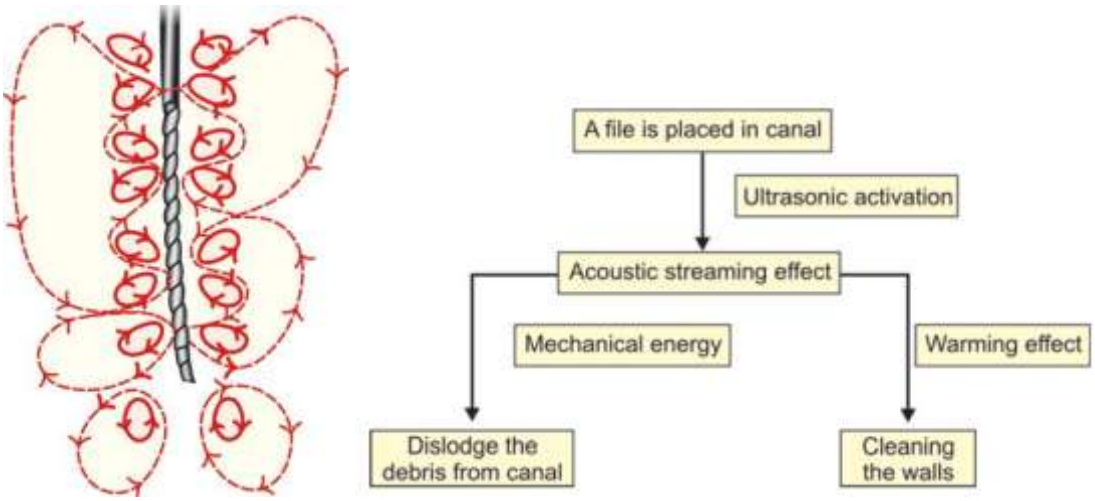


Figure 64. Ultrasonic irrigation

Electrochemically Activated Solution. It is one of newer irritant solution which is produced from the tap water and low concentrated salt solutions. Further, electrochemical treatment results in synthesis of two type of solutions, i.e. anolyte (produced in anode chamber) and catholyle (produced in cathode chamber). Anolyte solution has also been termed as super oxidized water or oxidative potential water but nowadays neutral and alkaline solutions has been recommended for clinical application.

Advantages of electrochemlcally activated solution

- ✓ Nontoxic to biological tissues
- ✓ Effective with wide range of microbial spectra.

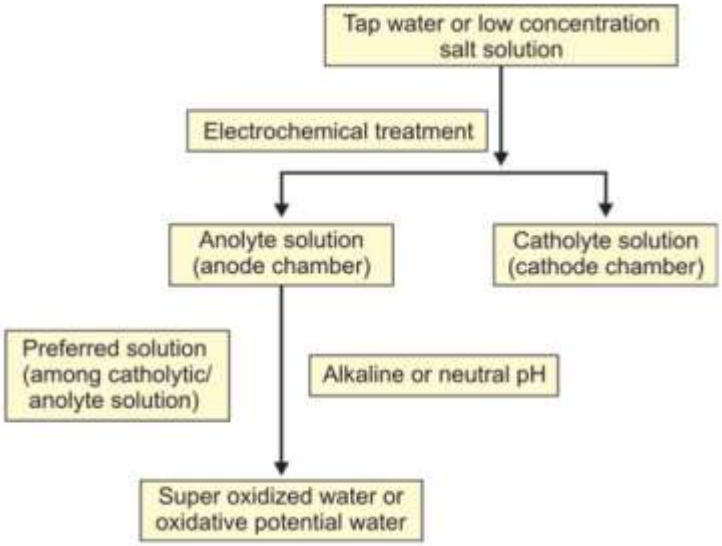


Figure 65. Electrochemically activated solution

Ozonated Water Irrigation

- Ozonated water is newer irritant solution which is shown Co be powerful antimicrobial agent against bacteria, fungi, protozoa and viruses.
- It is suggested that ozonated water may prove to be uselul in controlling oral infectious microorganism.

Advantages of ozonated water

- Its potency
- Ease of handling
- Lack of mutagenicity
- Rapid microbcaI effects.

Ruddle's Solution. It is a new experimental irrigating solution, introduce in the endodontics in an attempt to visualize the microanatomy of the canal system.

Composition of Ruddle's solution

- 17%EDTA 5% NaOCI
- Hypaque which is an aqueous solution of iodide salts, i.e., ditrizoate and sodium iodine.

Mechanism of Action

1. The solvent action of sodium hypochlorite, improved penetration due to EDTA and radiopacitv because of hypaque helps to visualize the shape and microanatomy of canals and dentin thickness during endodontic therapy.
2. The solvent action of sodium hypochlorite clears the contents ol root canal system and thus enables hypaquc component to flow into every nook and corner of the canal system such as fracture, missed canals and defective restoration.

So, Ruddle's solution can be helpful for improving diagnostic accuracy, treatment planning, management of procedural accidents, but further studies are needed to prove it as effective irrigating solution.

Photoaciivatcd disinfection (PAD) is a breakthrough in the fight against pathogenic bacteria. It is a fast, effective and minimally invasive disinfection system which is considered to kill more than 99.99% of bacteria in the endodontic biofilm.

Mechanism of PAD. Here, low powered laser light is transmitted through the disposable fiberoptic tip to activate the PAD antibacterial solution. Within 1 to 3 minutes, the PAD system eliminates more than 99.99% bacteria found in root canals.

Advantages of PAD

- ✓ Most effective antimicrobial agent.
- ✓ Effectively kills gram negative, gram-positive, aerobic and anaerobic bacterias, in other words it eliminates all types of bacteria.
- ✓ Overcomes the problems of antibiotic resistance.

- ✓ Kills bacteria present in complex biofilm such as subgingival plaque which is typically resistant to action to antimicrobial agents.
- ✓ Does not pose any thermal risk due to low power of PAD laser
- ✓ Does not cause any sensitization
- ✓ Neither the PAD solution nor its products are toxic to patients

Figure 66. PAD system

Question 5. Method of root canal system irrigation

Following points should be in mind while irrigating the canal:

1. The solution must be introduced slowly and passively into the canal.
2. Needle should never be wedged into the canal and should allow an adequate backflow.
3. Blunted needle of 25gauge or 27gauge are preferred.
4. In case of small canals, deposit the solution in pulp chamber. Then tile will carry the solution into the canal. Capillary action of narrow canal will slain the solution. To remove the excess fluid, either the aspirating syringe or 2 x 2 inches folded gauge pad is placed near the chamber. To further dry the canal, remove the residual solution with paper point.
5. Canal size and shape are crucial for irrigation of the canal. For effective cleaning of apical area, the canals must be enlarged to size 30 or larger size.
6. Regardless of delivery system, irrigants must never be forcibly inserted into apical tissue rather gently placed into the canal.
7. For effective cleaning, the needle delivering the solution should lie in close proximity to the material to be removed.
8. In case of large canals, the tip of needle should be introduced until resistance is felt, then withdraw the needle 2 to 3 mm away from that point and irrigate the canal passively. For removal of the solution, sterile gauge pack or paper points should be used.

9. In order to clean effectively in both anterior and posterior teeth canals, a blunt bend of 30° in the center of needle can be given to reach the optimum length to the canal.
10. Volume of irrigant is more important than concentration or type of irrigant.

Figure 67. 30^0 angle bend given in irrigation needle for efficient irrigation

Different delivery systems for irrigation:

- Stropĸo irrigator
- 27-gauge needle with notched tip
- Needle with bevel
- Monojet endodontic needle:
  a) 23 gauge
  b) 27-gauge
- ProRinse 25, 28, 30 gauge probes
- Ultrasonic handpiece.

Ideal properties of irrigating needle

An irrigating needle should:

- ✓ Be blunt
- ✓ Allow back flow
- ✓ Be flexible
- ✓ Be longer in length
- ✓ Be easily available
- ✓ Be cost-effective.

Different Needle Designs

Stropko Irrigator. In this system, combination of delivery and recovery of irrigant are present in one probe. Here the needle delivers the solution and an aspirator held in same sheath retrieves the irrigant.

27-Gauge Needle with Notched Tip. This needle is preferred as its notched tip allows backflow of the solution and does not create pressure in the periapical area. So, it ensures optimum cleaning without damage to periapical area.

Needle with bevel, if gets lodged into the canal, there is risk of forcing irrigant past the apex.

Monojet Endodontic Needle. This needle is also considered to be efficient one as the long blunt needles can be inserted to the lull length of the canal to ensure optimum cleaning. Hie only drawback observed is that if needles are placed near to the periapical area, it can cause damage.

ProRinse probes. This probe is proved to be highly effective in all gauges but 27 gauge notch tip needle is proved to be highly effective as it can clean the periapical area without placing near the apical foramen. Its efficiency lie in its design as it has a blunt tip, with lumen 2 mm from the tip. Fluid from the lumen creates turbulence in all directions.

Microbrushes and Ultrasonic. In this, bristles are attached to braided wires or flexible plastic cores. These microbrushes can be used a rotary or ultrasonic end brushes. These microbrushes have tapers like nonstandardized gutta-percha cones. These are used in conjunction with sodium hypochlorite and EDTA to produce clean canals.

Precautions to be taken while irrigation:

1. Avoid wedging the needle into the canal
2. Avoid forcing the solution into the canal
3. Avoid placing the needle beyond the apical area or very near to apical area
4. Avoid using larger gauge needle
5. Avoid using metallic, autoclavable syringe as they are more prone to breakage

Figure 68. Needle with notched tip

Figure 69. Needle with bevel

Figure 70. Monojet endodontic needle

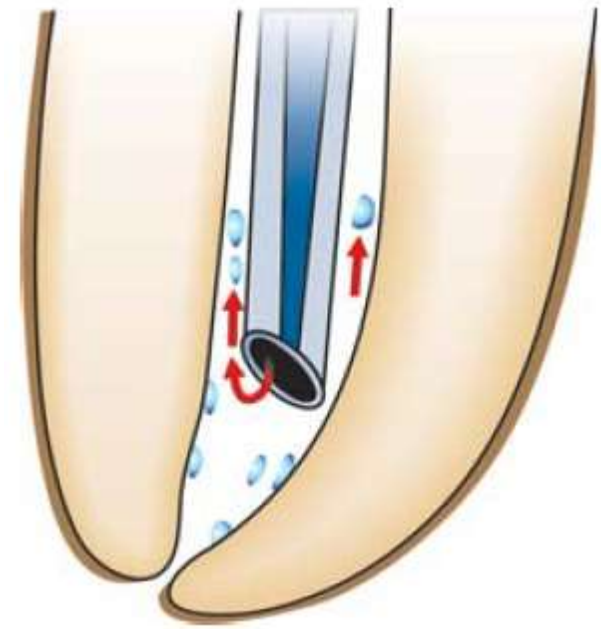


Figure 71. Needle should not be wedged into the canal

Question 6. Intracanal medicaments

Originally, endodontics was mainly a therapeutic procedure in which drugs were used to destroy microorganisms, fix or mummify vital tissue and aflect the sealing of the root canal space.

The drugs commonly used were caustics such as phenol and its derivatives which were shown to produce adverse effects on the periapical (issues. Gradually, the reliance on drugs has been replaced by emphasis on thorough canal debridement. But drugs are still being used as intra- treatment dressings, although an ever increasing number of endodontists use them only for symptomatic cases. Functions of intracanal medicaments:

1. Destroy the remaining bacteria and also limits the growth of new arrivals.
2. Useful in treatment of apical periodontitis in cases of inflammation caused due to over instrumentation.

Indications of using intracanal medicaments

1. To remove the remaining microorganisms from the pulp space
2. To dry the weeping canals
3. To act as barrier against leakage from an interappointment dressing.
4. To neutralize the tissue debns.

Desirable properties of an intracanal medicaments It should:

1. Be effective germicide and fungicide
2. Be nonirritating to pulpal tissue
3. Remain stable in the solution
4. Have prolonged antimicrobial action
5. Remain active in presence of blood and pus, etc.

6. Have low surface tension
7. Not interfere with repair of periapical tissue
8. Not stain tooth
9. Be capable of inactivation in the culture media
10. Not induce immune response.

Characteristics of intracanal medicaments

Essential Oils

Eugenol. It has been used in endodontics for many years. It it a constituent of most root canal sealers and is used as a part of many temporary sealing agents. This substance is the chemical essence of oil of clove and is related to phenol. Effects of eugenol are dependent on tissue concentrations of the eugenol. These are divided into low dove (beneficial effects) and high dose (toxic effects).

Low doses show anti-inflammatory activity while high doses exert cytotoxic effects.

Uses of eugenol:

1. Used as an intracanal medicament.
2. Used as a root canal sealers.
3. Part of temporary scaling agents.
4. Chemical essence of oil of clove
5. Effects depend on tissue concentrations of the eugenol.
6. Anti-inflammatory activity—at low dose
7. Cytotoic effects- at high dose

Phenolic Compounds

Phenol. It was used for many years for its disinfectant and caustic action. However, it has strong inflammatory potential, so, at present, it is rarely used as an intracanal medicament.

Liquefied phenol (Carbolic acid) consists of 9 parts of phenol and 1 part of water.

Uses:

- ✓ It is used for disinfection before periapical surgery.
- ✓ It is also used for cauteizing tissue tags that resist removal with broaches or files.

Parachlorophenol has been a very popular component of dressing as phenol is no longer used in endodontics because of its high toxicity to efficacy ratio.

Composition

- ✓ This is substitution product of phenol in which chlorine replaces one of the hydrogen atoms (C_4H_4OHCI).
- ✓ On trituration with gum camphor, these products combine to form an oily liquid.

Concentration: one percent aqueous solution is preferred.

Used as a dressing of choice for inlected tooth.

Camphorated Monoparachlorophenol (CMCP). It is probably the most commonly used medicament in endodontics, presently, even though its use has decreased considerably in the past few years. Camphor is added to parachlorophenol (PCP) because it:

1. Has diluent action
2. Prolongs the antimicrobial effect
3. Reduces the irritating effect of PCP
4. Serves as a vehicle for the solution.

Used as a dressing of choice for infected teeth.

Cresatin possesses the same desirable qualities and actions as that of CMCP, yet even less irritating to periapical tissues.

Composition: this is substance is clear, stable, oily liquid of low volatile nature known as metacresyl acetate.

Aldehydes:

1. Formaldehyde, paraformaldehyde and glutaraldehyde are commonly used intracanal medicaments in root canal therapy.
2. These are water-soluble protein denaturing agents and are considered among the most potent disinfectants.
3. Ihey are mainly applied as disinfectants for surfaces and medical equipment which cannot be sterilized, but they are quite toxic and allergic and some even may be carcinogenic.

Formocresol contains forrmaldehyde as its main ingredient and is still widely used medicament for pulpotomy procedures in primary teeth but its toxic and mutagenic properties are of concern.

Composition of formocresol

- ✓ Formaldehyde - 19%
- ✓ Cresol - 35%
- ✓ Water and glyecerine - 46%

Uses: used as dressing for pulpotomy to fix the retained pulpal tissue.

Paraformaldehyde:

1. It is polymeric form of formaldehyde and is commonly found as component of some root canal obturating material like endomethasone.
2. It slowly decomposes to give out formocresol, its monomer.
3. Its properties are similar to formaldehyde that is toxic, allergenic and genotoxic in nature.

Clinical Tips. All phenolic and similar compounds are highly volatile with low surface tension. If they are placed on a cotton pellet in the pulp chamber, vapors will penetrate the entire canal preparation. Thereiofe, paper point is not needed for their application. Only tiny quantity of medication is

needed for effectiveness, otherwise, chances of periapical irritation are increased.

Calcium Hydroxide. The use of calcium hydroxide in endodontics was introduced by Hermann in 1920. It has acquired a unique position in endodontics. Alter its successful clinical applications for variety of indications, multiple biological functions have been attributed to calcium hydroxide.

Table24. **Effects of Calcium Hydroxide**

Physical	− Acts as a physical barrier for ingress of bacteria. − Destroys the remaining bacteria by limiting space for multiplication and holding substrate for growth.
Chemical	− It shows antiseptic action probably because of its high pH and its leaching action on necrotic pulp tissues. It also increases the pH of circumpulpal dentin when placed into the root canal. − Suppresses enzymatic activity and disrupts cell membrane − Inhibits DNA replication by splitting it. − It hydrolyses the lipid part of bacterial lipopcolysaccharide (LPS) and thus inactivates the activity of LPS. This is a desirable effect because dead cell wall material remains alter the killing of bacteria which may cause infection.

Calcium hydroxide is available in:

- *Paste form:* Single paste or in combination with iodoform.
- *Powder form*: Powder form is mixed with saline and anesthetic solution. For placement in root canals, it is coated with the help of paper points, spreaders or lentulo spirals.

Table 25. **Features of calcium hydroxide**

Indications	1. In weeping canals 2. In treatment of phoenix abscess 3. In resorption cases 4. For apexification 5. During pulpotomy 6. For nonsurgical treatment of periapical lesion 7. In cases of direct and indirect pulp capping 8. As sealer for obturation 9. To decrease postoperative pain after over instrumentation, it is used in combination with Ledermix
Advantages of	1. Inhibits root resorption

$Ca(OH)_2$,	2. Stimulates periapical healing 3. Encourage mineralization
Disadvantages of $Ca(OH)_2$ as intracanal medicament	1. Difficult to remove from canals 2. Decreases setting time of zincoxide eugenol based cements

Use of Calcium Hydroxide in Weeping Canal Cases

Sometimes, a tooth undergoing root canal treatment shows constant clear or reddish exudation associated with periapical radiolucency. Tooth can be asymptomatic or tender on percussion. When opened in next appointment, exudates stops but it again reappears in next appointment. This is known as "Weeping Canal".

In these cases, tooth with exudates is not ready for filling, since culture reports normally show negative bacterial growth so, antibiotics are of no help in such cases. For such teeth, dry the canals with sterile absorbent paper points and place calcium hydroxide in the canal. By next appointment, one finds a dry canal, ready for obturation. It happens because pH of periapical tissues is acidic in weeping stage which gets converted into basic pH by calcium hydroxide. Some say that caustic effect of calcium hydroxide burns the residual chronic inflamed tissue and also calcium hydroxide builds up the bone in the lesion due to its calcifying action.

Halogens include chlorine and iodine which are used in various formulations in endodontics. They are potent oxidizing agents with rapid bactericidal effects.

Chlorine

Sodium hypochlorite: this compound is sometimes used as an intracanal medicament. In general, the disinfectant action of halogens is inversely proportional to their atomic weights. Chlorine (lowest atomic weight), has the greatest disinfectant action among the members of this group. Chlorine disinfectants are not stable compounds because they interact rapidly with organic matter. Mentz found sodium hypochlorite as effective intracanal medicament as well as irrigant. As the activity of sodium hypochlorite is intense but of short duration, the compound should preferably be applied to the root canal every other day.

Iodides. Iodine is highly reactive in nature. It combines with proteins in a loosely bound manner so that its penetration is not impeded. It probably destroys microorganisms by forming salts that are inimical to the life of the organism. Iodine is used as iodine potassium iodide and in iodophors, which are organic iodine containing compounds that release iodine over time. It is also a very potent antibacterial agent of low toxicity, but may stain clothing if spilled. As iodophors, it was used in a paste formulation to serve as a

permanent root canal tilling. Current applications of iodine compounds are as an irrigating solution and short-term dressing in a 2percent solution of iodine in 4 percent aqueous potassium iodide and more recently, as a constituent in gutta percha points for filling.

Chlorhexidine gluconate has been widely used in periodontics because of its antibacterial activity. Its use as an irrigant solution has been compared with sodium hypochlorite.

Chlorhexidine exhibit substantivity (persistence in the area of interest), broadspectrum activity and low toxicity, these properties make it well suited (or irrigation and dressing applications in endodontics. Effective concentrations commonly used are in range of 0.2 to 2% range. Innovative attempts are being made to utilize the disinfecting properties of chlorhexidine in gutta-percha points.

PBSC Paste. As mentioned by Grossman. PBSC has enjoyed wide use among dentists. The constituents of PBSC paste are as follows:

Nystatin replaces sodium caprylate as the an antifungal agent and is available in form of PBSN. Both are available in a paste form that may be injected into root canals or impregnated on paper points. Because there is no volatility, the drug must be placed in the canal to have effect in that area.

PBSC may interfere with subsequent culturing procedures, therefore penicillinase may be added to culture media to inactivate penicillin. Reports of allergic reaction to the drug have been presented, if the patient reports history of allergy to any of the constituents, the drug should not be used. With the decline in popularity of intracanal drugs in general, and because ol the potential for sensitivity due to topical use of antibiotics, PBSN largely has fallen into disuse.

Sulfonamides. Sulfanilamide and Sulfathiazole are used as medicaments by mixing with sterile distilled water or by placing a moistened paper point into a Hulled jar containing the powder. Yellowish tooth discoloration has been reported after use. Sulfonamides are usually recommended while giving closed dressing in a tooth which had been left open after an acute periapical abscess.

N_2 by Sargent. It is a compound consisting of paraformaldehyde as the main ingredient. It contains eugenol, phenyl mercuric borate and perfumes. Antibacterial effect of N_2 is short lived and dissipated in 7 to 10 days.

Grossman paste. Composition:

- Potassium penicillin G
- Bacitracin
- Streptomycin sulfate
- Sodium caprylate
- Silicon fluid
- Nystatin

Chloramines-T. It is a chlorine compound with good antimicrobial. It is used in the concentration of 5%. If remains stable for long period of time. It can be used to disinfect gutta percha points, and can be used in patients allergic to iodine.

Quaternary Ammonium Compounds. They are positively charged compounds which attract negatively charged microorganisms they have low surface tension, e.g. Aminoacridine.

Aminoacridine is a mild antiseptic which is more effective than creation but less effective than CMCP. It is used more as an irritant than intracranial medicament.

Corticosteroid-antibiotic Combinations

1. Medications that combine antibiotic and corticosteroid elements are highly effective in cases of over instrumentation.
2. They must be placed into the inflamed periapical tissue by a paper point or reamer.
3. Tetra-Cortril, Cortisporin, Mycolog. and other combinations are available for their use in endodontics.
4. Ledermix is one of best known corticosteroid-antibiotic combination.
5. The corticosteroid constituent reduces the periapical inflammation and gives almost instant relief of pain to the patient who complains of extreme tenderness to percussion after canal instrumentation.
6. The antibiotic constituents present in the corticosteroid antibiotic combination prevent the overgrowth of microorganisms when the inflammation subsides.

Placement of intracanal medicament:

1. Copiously irrigate the canal to remove debris present if any
2. Place the master apical file in the canal
3. Dry the canal using absorbent paper points
4. Place the intracanal medicament on a sterile cotton pellet and place it in the pulp chamber
5. Over this another sterile cotton pellet is placed, which is finally sealed with a temporary restorative material

Limitations of Intracanal Medicaments:

- ✓ For an intracanal, medicament to be effective, it should remain active during the time of inter appointment, which does not happen not in every case.
- ✓ Clinical effectiveness of sustained release delivery systems is unknown.
- ✓ Therapeutic action of medicaments depend upon its direct contact with tissues. But these substances may not reach all the areas where bacteria and tissues are present.

Tests to the topic

1. An ideal irrigant solution must fulfill the following criteria:

a. It must have broadspectrum antimicrobial properties.
b. It must aid in the debridement of the canal system.
c. It should have the ability to dissolve necrotic tissue or debris.
d. It should be able to effectively sterilize the root canal (or at least disinfect them).
e. All answers are right.

2. Commonly used irrigating solutions

a. Water.
b. Local anesthetic.
c. Chlorhexidine.
d. Hydrogen peroxide, carbamide peroxide.
e. Ethylene diamine tetra acetic acid (edta).

3. In what concentration sodium hypochlorite is used for root canal system irrigation?

a. 0,1%.
b. 0,5%.
c. 3-5%.
d. 6%.
e. All answers are right.

4. In what concentration hydrogen peroxide is used for root canal system irrigation?

a. 0,1%.
b. 0,5%.
c. 3%.
d. 6%.
e. All answers are right.

5. In what concentration chlorhexidine is used for root canal system irrigation?

a. 0,1%.
b. 0,5%.
c. 3-5%.
d. 6%.
e. 2%.
f. All answers are right.

6. Calcium hydroxide is available in:

a. Powder form.
b. Paste form.
c. All answers are right.

7. Indications of calcium hydroxide are:

a. In weeping canals.
b. In treatment of phoenix abscess.
c. In resorption cases.
d. For apexification.
e. During pulpotomy.
f. All answers are right.

8. Newer methods of root canal irrigation are:

a. Ultrasonic irrigation.
b. Electrochemically activated solution using.
c. Ozonated water irrigation.
d. Photoactivated disinfection.
e. Irrigation with chlorhexidine.

9. Desirable properties of an intracanal medicaments are:

a. Be effective germicide and fungicide.
b. Be nonirritating to pulpal tissue.
c. Remain stable in the solution.
d. Stimulate microorganisms growth.
e. Have prolonged antimicrobial action.
f. Irritate periapical tissues

10. Grossman paste consists of:

a. Potassium penicillin G.
b. Bacitracin.
c. Streptomycin sulfate.
d. H_2O.
e. Silicon fluid.
f. All answers are right.

LESSON 15. METHODS OF ROOT CANAL SYSTEM OBTURATION. MATERIALS USED FOR OBTURATION

The questions to be studied for the learning of the topic:

1. Obturation of root canal system, objectives, features of an ideal root canal obturation.
2. Materials used for root canal obturation.
3. Root canal sealers.
4. Methods of obturation.
5. Methods of root canal obturation with cold gutta-percha.
6. Warm methods of root canal obturation with gutta-percha.
7. Solid carrier obturation technique.

Question 1. Obturation of root canal system, objectives, features of an ideal root canal obturation

The success in endodontic treatment is based on proper diagnosis and treatment planning, knowledge of anatomy and morphology, debridement, sterilization and obturation. The process of cleaning and shaping determines both the degree of disinfection and the ability to obturate the radicular space, obturation is therefore a re1ection of the cleaning and shaping and an obturant (obturating material) must seal the root canal system three dimensionally so as to prevent tissue 1uids from percolating in the root canal and toxic byproducts from both necrotic tissue and microorganisms regressing into the periradicular tissues.

The obturation of the prepared space have been achieved by using a wide variety of materials selected for their intrinsic properties and handling characteristics. These core materials have been classified as cements, pastes, plastics or solids. Gutta-percha, in its various forms, has remained the paragon as a root canal filling material during the course of last century. The development of core materials and delivery techniques has generated carrier-based gutta-percha and resin-based system. These filling materials are combined with sealers to provide an adequate obturation of the root canal space that ideally prevents the emergence of endodontic disease and encourages peripheral healing when pathosis is present. This process can only succeed if the sealed root canal space prevents further ingress of bacteria, entombs remaining microorganisms and prevents their survival by obstructing the nutrient supply. Root canal obturation involves the three dimensional filling of the entire root canal system and is a critical step in endodontic therapy.

There are two main **purposes of obturation** - the elimination of all avenues of leakage from the oral cavity or the periradicular tissues into the root canal system, and sealing within the root canal system of any irritants

that remain after appropriate shaping and cleaning of the canals, thereby isolating these irritants. Pulpal demise, subsequent periradicular infection result from the presence of microorganisms, microbial toxins and metabolites and the products of pulp tissue degradation. Failure to eliminate these etiological factors and further irritation as a result of continued contamination of the root canal system are the prime reasons for the failure of nonsurgical and surgical root canal therapy.

Objectives of root canal obturation

1. Total debridement of the pulpal space.
2. Development of a fluid tight seal at the apical foramen.
3. Total obliteration of root canal.

Features of an ideal root canal obturation

1. Three dimensional obturation close to CDJ.
2. Radiographically, filling should be seen 0.5 to 0.75 mm from radiographic apex.
3. Minimal use of a root canal sealer which is confined to root canal.

Question 2. Materials used for root canal obturation

An ideal root canal filling should be capable of completely preventing communication between the oral cavity and periapical tissue. Root canal sealers should be biocompatible or well tolerated by the tissues in their set state, and are used in conjunction with the core filling material to establish an adequate seal. Grossman (1982) grouped acceptable filling materials into plastics, solids, cements and pastes.

He also delineated 10 requirements for an ideal root canal filling material, these are as follows:

1. Easily introduced into a root canal.
2. Seal the canal laterally as well as apically.
3. Not shrink after being inserted.
4. Impervious to moisture.
5. Bacteriostatic or at least not courage bacterial growth.
6. Radiopaque
7. Non-staining the tooth structure.
8. Non-irritating.
9. Sterile/easily sterilized immediately before obturation.
10. Easily removed from the root canal if necessary.

Different endodontic materials have been advocated for obturation of the radicular space. A variety of core materials have been used in conjunction with a sealer/cement, the most common method of obturation involves gutta-percha as a core material. The properties of an ideal obturation material were outlined by Grossman (mentioned above). Historically a variety of material

has been employed. A common solid material used was the silver cone, though gold, iridoplatinum, tantalum, titanium are also available.

Materials used for root canal filling

- ✓ Silver cones.
- ✓ Gutta-percha.
- ✓ Custom cones.
- ✓ Resilon.
- ✓ Root canal sealers.

Silver Cones

- Jasper (1941) introduced silver cones which he claimed produced the same success rate as gutta-percha and were easier to use.
- Rigidity provided by the silver cones made them easy to place and permitted length control.
- They were mainly used for teeth with fine, tortuous, curved canals which make the use of gutta-percha difficult.
- But nowadays their use has been declined, because of corrosion caused by them. Silver cones contain traces of metal like copper, nickel which add up the corrosion of the silver points.

Indications. Due to stiffness of silver cones, these are mainly indicated in round, tapered and narrow canals, for example maxillary first premolars or buccal roots of maxillary molars and mesial root of mandibular molars if they are straight.

Contraindications. Silver cones cannot conform with the shape of root canal because they lack plasticity; so their use is not indicated:

- For obturation of anterior teeth, single canal premolars, or large single canals in molars.
- In young teeth having large ovoid canals.

Gutta-percha was initially used as a restorative material and later developed into an indispensable endodontic filling material. Gutta-percha was earlier used as splints for holding fractured joints, to control hemorrhage in extracted sockets, in various skin diseases such as psoriasis, eczema and in manufacturing of golf balls.

Chemically pure gutta-percha exists in two different crystalline forms, i.e. α and β which differ in molecular repeat distance and single bond form. Natural gutta-percha coming directly from the tree is in α-form while the most commercial available product is in β-form.

Table 26. **Forms of gutta-percha**

Alpha form	1. Pliable and tacky at 56°–64°. 2. Available in form of bars or pellets. 3. Used in thermoplasticized obturation technique.
Beta form	1. Rigid and solid at 42^0–44^0. 2. Used for manufacturing gutta-percha points and sticks.
Amorphous form	Exists in molten stage.

Phases of gutta-percha

These phases are interconvertible

1. α - runny, tacky and sticky (lower viscosity)
2. β - solid, compactable and elongatable (higher viscosity)
3. ɣ - unstable form
4. On heating, gutta-percha expands which accounts for increased volume of material which can be compacted into the root canal.
5. Gutta-percha shrinks as it returns to normal temperature. So, vertical pressure should be applied in all warm guttapercha technique to compensate for volume change when cooling occurs.
6. Aging of gutta-percha causes brittleness because of the oxidation process. Storage under artificial light also speeds up their deterioration.
7. Brittle gutta-percha can be rejuvenated by a technique described by Sorien and Oliet. In this, gutta-percha is immersed in hot water (55°C) for one or two seconds and then immediately immersed in cold water for few seconds.
8. Gutta-percha cannot be heat sterilized. For disinfection of gutta-percha points, they should be immersed in 5.25 percent NaOCl for one minute.
9. After this, gutta-percha should be rinsed in hydrogen peroxide or ethyl alcohol to remove crystallized NaOCl before obturation, as these crystallized particles impair the obturation.
10. Gutta-percha should always be used with sealer and cement to seal root canal space as gutta-percha lacks adhering qualities.
11. Gutta-percha is soluble in certain solvents like chloroform, eucalyptus oil, etc. This property can be used to plasticize gutta-percha by treating it with the solvent for better filling in the canal. But it has shown that gutta-percha shrinks (1-2%) when solidifies.
12. Gutta-percha also shows some tissue irritation which is due to high content of zinc oxide.

Current Available Forms of Gutta-percha

1. Gutta-percha points: Standard cones are of same size and shape as that of ISO endodontic instruments.
2. Auxiliary points: Non-standardized cones; perceive form of root canal.

3. Greater taper gutta-percha points: Available in 4 percent, 6 percent, 8 percent and 10 percent taper.
4. Gutta-percha pellets/bars: They are used in thermoplasticized gutta-percha obturation, e.g. obtura system.
5. Precoated core carrier gutta-percha: In these stainless steel, titanium or plastic carriers are precoated with alpha-phase gutta-percha for use in canal, e.g. thermafil.
6. Syringe systems: They use low viscosity gutta-percha, e.g. Success-fil and alpha seal.
7. Gutta flow: In this gutta-percha powder is incorporated into resin based sealer.
8. Gutta-percha sealers like chloropercha and eucopercha: In these, gutta-percha is dissolved in chloroform/eucalyptol to be used in the canal.
9. Medicated gutta-percha: Calcium hydroxide, iodoform or chlorhexidine diacetate containing gutta-percha points.

Advantages of gutta-percha

- ✓ Compatibility: Adaptation to canal walls
- ✓ Inertness: Makes it non-reactive material
- ✓ Dimensionally stable
- ✓ Tissue tolerance
- ✓ Radiopacity: Easily recognizable on radiograph
- ✓ Plasticity: Becomes plastic when heated
- ✓ Dissolve in some solvents like chloroform, eucalyptus oil, etc.

This property makes it more versatile as canal filling material.

Disadvantages of gutta-percha

- ✓ Absence of rigidity: Bending of gutta-percha is seen when lateral pressure is applied. So, difficult to use in smaller canals
- ✓ Easily displaced by pressure
- ✓ Absence adhesive quality.

The resin-based obturation systems Epiphany (Pentron Clinical Technologies), RealSeal (Sybronendo), and Resinate (Obtura Spartan, earth City, Mo) have been introduced as alternatives to gutta-percha. Resilon is high performance industrial polyurethane that has been adapted for dental use. The resin sealer bonds to a resilon core, and attaches to the etched root surface. Whether a monoblock is achievable, remains controversial. The system resembles gutta-percha and can be placed by lateral compaction, warm lateral or vertical compaction, or thermoplastic injection. It consists of a resin core material (resilon) composed of polyester, difunctional methacrylate resin, bioactive glass, radiopaque fillers, and a resin sealer. Resilon is nontoxic, nonmutagenic, and biocompatible. The core material is available in nonstandard and standard cones and pellets for use in thermoplastic techniques.

Figure 72. Real seal obturation system with Resilon

Question 3. Root canal sealers

Root canal sealers are necessary to seal the space between the dentinal wall and the obturating core interface. Sealers also fill voids and irregularities in the root canal, lateral and accessory canals, and spaces between gutta-percha points used in lateral condensation. Sealers also serve as lubricants during the obturation process.

Functions of root canal sealers. Root canal sealers are used in conjunction with filling materials for the following purposes:

1. Antimicrobial agent: All the commonly used sealers contain some antibac-terial agent; so a germicidal quality is excreted immediately after its placement.

2. Sealers are needed to fill in the discrepancies between the filling material and the dentin walls.

3. Binding agent: Sealers act as binding agent between the filling material and the dentin walls.

4. As lubricant: With the use of semisolid materials, the most important function for the sealer to perform is its action of lubrication.

5. Radiopacity: All sealers display some degree of radiopacity; thus they can be detected on a radiograph. This property can disclose the presence of auxiliary canals, resorptive areas, root fractures, and the shape of apical foramen.

6. Certain techniques dictate the use of a particular sealer. The choropercha technique, for instance, uses materials as sealer as well as a solvent for the master cone. It allows the shape of normal gutta-percha cone to be altered according to the shape of the prepared canal.

Acceptable methods of placing the sealer into the canal include the following:

1. Placing the sealer on the master cone and pumping the cone up and down in the canal.

2. Placing the sealer on a file and spinning it counterclockwise.

3. Placing the sealer with a lentulo spiral.

4. Using a syringe.

Properties of an ideal sealer:

1. Exhibits tackiness when mixed to provide good adhesion between it and the canal wall when set.
2. Establishes a hermetic seal.
3. Radiopaque, so that it can be seen on a radiograph.
4. Very fine powder, so that it can mix easily with liquid.
5. No shrinkage on setting.
6. No staining of tooth structure.
7. Bacteriostatic, or at least does not encourage bacterial growth.
8. Exhibits a slow set.
9. Insoluble in tissue fluids.
10. Tissue tolerant; that is, nonirritating to periradicular tissue.
11. Soluble in a common solvent if it is necessary to remove the root canal filling.
12. The sealer also must have cohesive strength to hold the obturation material together.
13. It should not provoke an immune response in periradicular tissue.
14. It should be neither mutagenic nor carcinogenic.
15. It should not provoke an immune response in periradicular tissue.
16. It should be neither mutagenic nor carcinogenic.

There are numerous classifications of root canal sealers: Sealers may be widely **classified according to their composition**:

1. Eugenol.
2. Non-eugenol.
3. Medicated.

Table 27. **Classifications of root canal sealers**

I. Eugenol group may be divided into subgroups, namely:	***Silver containing cements:*** a) Kerr sealer (Rickert, 1931); b) Procosol radiopaque silver cement (Grossman, 1936). ***Silver free cements:*** a) Procosol nonstaining cement (Grossman, 1958); b) Grossman's sealer (Grossman, 1974); c) Tubliseal (Kerr, 1961); d) Wach's paste (Wach).
II. Non-eugenol.	These sealers do not contain eugenol and consist of a wide variety of chemicals. Examples: Chloropercha, glass ionomer sealers, polycarboxylate sealers.
III. Medicated.	These include the group of root canal sealers which have therapeutic properties.

Grossman's sealer classification:

1. Zinc oxide resin cements.
2. Calcium hydroxide cements.
3. Paraformaldehyde cements.
4. Pastes.

According to the intended use:

Table28.**Cohen's sealer classification** (ADA and ANSI).

Type I: Material's intended to be used with core material.	
Class I	Includes materials in the form of powder and liquid that set through a non-polymerizing process.
Class II	Includes materials in the form of two pastes that set through a non-polymerizing process.
Class III	Includes polymers and resin systems that set through polymerization.
Type II: Intended for use with or without core material or sealer.	
Class I	Powder and liquid- non-polymerizing.
Class II	Paste and paste- non-polymerizing.
Class III	Metal amalgams.
Class IV	Polymer and resin systems polymerization.

Clark's sealer classification:

1. Absorbable.
2. Non-absorbable

Ingle's sealer classification:

1. Cements.
2. Pastes.
3. Plastic.
4. Experimental sealers. The most popular sealers are zinc oxide-eugenol formulations, calcium hydroxide sealers, glass ionomers, and resins.

Zinc oxide eugenol cements. Many endodontic sealers are simply zinc oxide eugenol (ZnOE) cements that have been modified for endodontic use. Zinc oxide eugenol sealers will absorb if extruded into the periradicular tissues. They exhibit a slow setting time, shrinkage on setting, solubility, and they can stain tooth structure. ZnOE sealers have demonstrated antimicrobial properties on a variety of microorganisms, including Enterococcus faecalis suspensions and anaerobic bacteria even 7 days after mixing. Apparently, eugenol is the main antimicrobial agent. Formaldehyde-releasing ZnOE root canal sealers should not be used anymore because of their inherent toxic potential. ZnOE-based sealers are easy to handle. They can be mixed to a smooth paste, which allows enough time for obturation and control

radiography before setting. Removal can be performed with organic solvents. The radiopacity of different ZnOE sealers can be regarded as sufficient.

Advantages of ZnOE-based sealers:

1. Easy to manipulate.
2. Shows only slight dimensional change.
3. Radiopaque.
4. Germicidal properties.
5. Minimal staining.
6. Ample working time.

Disadvantages of ZnOE-based sealers:

1. Irritant to periapex.
2. Not easily absorbed from the apical tissues.

Examples: Endofill (Dentsply-Mallefer) and Endométhasone (Septodont).

Calcibiotic root canal sealer (CRCS.) CRCS is a zinc oxide, eugenol-eucalyptol sealer to which calcium hydroxide has been added for its osteogenic effect. CRCS takes three days to set fully in either dry or humid environment. Because of little water resorption property, it is quite sTable Though sealing is improved, but since calcium hydroxide is not released from the cement, its main role (osteogenic effect) becomes questionable.

Advantages of CRCS:

1. Biocompatible.
2. Takes three days to set.
3. Stable in nature.
4. Shows little water resorption.
5. Easily disintegrates in tissues.

Disadvantages of CRCS:

1. Extruded sealer is resistant to resorption by tissue fluids.
2. Shows minimal antibacterial activity.

Calcium hydroxide sealers. These sealers are promoted as having therapeutic effects because of their $Ca(OH)_2$ content. It was thought that these sealers would exhibit antimicrobial activity and have osteogenic - cementogenic potential. The antimicrobial effect of Ca(OH)2 is thought to occur because of its ability to release hydroxyl ions and by having a high pH. These materials have been shown to have similar sealing ability to zinc oxide and eugenol preparations; however, long-term exposure to tissue fluid may possibly lead to dissolution of the material as calcium hydroxide is leached out. Handling properties of calcium hydroxide sealers are adequate; the radiopacity is regarded as sufficient. The material can be removed from the root canal with common rotary instruments.

Advantages of calcium hydroxide sealers:

1. Induce mineralization.
2. Induce apical closure via cementogenesis.
3. Inhibit root resorption subsequent to trauma.
4. Inhibit osteoclast activity via an alkaline pH.
5. Seal or prevent leakage as well as or better than ZOE sealers.
6. Less toxic than ZOE sealers.

Disadvantages of calcium hydroxide sealers:

1. Calcium hydroxide content may dissolve, leaving obturation voids.
2. There is no objective proof that a calcium hydroxide sealer provides any added advantage of root canal obturation or has any of its desirable biological effects.
3. Although calcium hydroxide has dentin regenerating properties, the formation of secondary dentin along the canal wall is prevented by the absence of vital pulp tissue.

Examples: SealApex (Sybron Endo/Kerr; Orange, Calif.), LIFE (Sybron Endo/Kerr; Orange, Calif.), Vitapex (NEO Dental, Japan), Apexit Plus(Ivoclar, Vivadent, Fürstentum, Schaan, Liechtenstein) and Sealapex(Sybron-Endo, Glendora, CA, USA).

Hydraulic calcium silicate cements. Hydraulic calcium silicate cements (HCSCs), well known as MTA (mineral trioxide aggregate) sealers. Hydraulic calcium silicate cements were developed more than 20 years ago. Their composition is largely based on Portland cement components (di- and tri-calcium silicate, Al- and Fe-silicate). Some hydraulic calcium silicate-based materials containing additional components (setting modulators, radiopacifying agents, drugs, etc.).

They have important properties such as the ability to set and to seal in moist and blood-contaminated environments, biocompatibility, adequate mechanical properties, etc. Their principal limitations are long setting time, low radiopacity and difficult handling. Hydraulic calcium silicate cements regulate the differentiation of osteoblast, fibroblasts, cementoblasts, odontoblasts, pulp cells and many stem cells. They can induce the chemical formation of a calcium phosphate/apatite coating when immersed in biological fluids. These properties have led to a growing series of innovative clinical applications such as root-end filling, pulp capping and scaffolds for pulp regeneration, root canal sealer, etc.

The material is rather difficult to place and the working time may be short. Special MTA endodontic carriers have been developed to facilitate placement and condensation.

Figure 73. Special carrier for MTA

Examples: ProRoot Endo Sealer (Dentsply, Tulsa, OK, USA), Endo-CPM-Sealer (EGEO SRL, Buenos Aires, Buenos Aires, Argentina) and MTA Fillapex (Angelus, Londrina, PR, Brazil).

Glass ionomer sealers. Glass ionomer cements were first introduced into dentistry in 1975 and since then they have been used in a wide range of clinical applications. The glass ionomers have been advocated for use in obturation because of their dentin-bonding properties. Conventional glass ionomers are dispensed in a powder form supplied with its own liquid. The powder is formed of fluoroaluminosilicate glass, while the liquid is an aqueous solution of a polyalkenoic acid, such as polyacrylic acid, although in later formulations, the acid may be added to the powder in a dried polymer form.

Advantages:

1. Optimal physical qualities.
2. Shows bonding to dentin.
3. Shows a minimum number of voids.
4. Low surface tension.
5. Optimal flow property.

Disadvantages: it cannot be removed from the root canal in the event of retreatment as there is no known solvent for glass ionomer. Examples: Ketac-Endo (3M/Espe; Minneapolis, Minn.).

Resin sealers have a long history of use, provide adhesion, and do not contain eugenol. The use of dentin bonding agents in root canal filling was introduced to enhance the endodontic resin. The use of dentin bonding agents in root canal filling was introduced to enhance the endodontic resin-based sealers adhesion to the root dentin. The newer endodontic methacrylate resin-based sealers (RealSeal, Epiphany) use a separate self-etching primer before application of flowable composites to the primed dentin; or else consist of a single product of the self- adhesive methacrylate sealer, incorporating a self-etching primer and a moderately filled flowable composite (MetaSEAL; RealSeal SE, Epiphany SE).

Epoxy-based sealers have been used for more than 40 years worldwide and their handling properties are usually considered to be good. Radiopacity is sufficient (6.6 mm Al). However, the materials set to a hard mass that, in a clinically relevant time, is virtually insoluble even for organic solvents. Therefore, this material must be used together with gutta-percha cones.

Examples: Diaket (3M/Espe; Minneapolis, Minn.), AH-26 (Dentsply/Mail-lefer, Tulsa, Okla).

Silicone sealers. The first of those materials was based on C-silicones (condensation cross-linking silicones); newer materials are based on A-silicones (addition cross-linking). Silicone sealers are supplied in capsules and after mixing can easily be injected into the canal followed by the insertion of gutta-percha.

Advantages:

1. Easy to penetrate.
2. Adjustable working time.
3. Low working viscosity.
4. Rubbery consistency.
5. Non-resorbable.

Disadvantages:

1. Cannot be used in presence of hydrogen peroxide.
2. The canal must be absolutely dry.
3. Shrinks upon setting but has affinity for flowing into open tubuli.
4. Difficult to remove from the canals.

Examples: RoekoSeal (Coltène/Whaledent, Germany). GuttaFlow(Coltène/Whaledent) is a cold flowable matrix that is triturated. It consists of gutta-percha added to RoekoSeal. The material is provided in capsules for trituration. The technique involves injection of the material into the canal, followed by placement of a single master cone. The material provides a working time of 15 minutes and it cures in 25 to 30 minutes.

Figure 74. RoekoSeal (Germany)

Bioceramic sealer is composed of zirconium oxide, calcium silicates, calcium phosphate monobasic, calcium hydroxide, and various filling and thickening agents. The material is available in a premixed syringe with calibrated intracanal tips. As a hydrophilic sealer it utilizes moisture within the canal to complete the setting reaction and it does not shrink on setting. It is biocompatible and exhibits antimicrobial properties during the setting reaction. The manufacturer advocates expressing the sealer into the coronal one third to one half of the canal and then seating the master gutta-percha cone.

Question 4. Methods of obturation

Today, most root canals are being filled with gutta-percha and sealers. These are the two basic procedures: lateral comor vertical compaction of warmed guttawarmed gutta-percha.

Table 29. **Methods of obturation**.

According to Grossman	1. Lateral condensation method 2. Vertical condensation method 3. Sectional method 4. Compaction method (mcSpadden) 5. Metal-core obturation 6. Silver-cone method 7. Stainless steel file method 8. Chemically plasticized gutta 9. Injection techniques of obturating canals 10. Hydron 11. Thermoplasticized gutta 12. Obtura II, Ultrafil.
According to Stock	1. Sectional 2. Single cone. 3. Multiple cone: cold/warm lateral condensation 4. Warm vertical condensation 5. Custom made 6. Gutta-percha with solvents 7. Thermal compaction 8. Injection molded thermo plasticized 9. Pastes alone.
According to Ingle	1. Apical third fillings 2. Light speed simplifill. 3. Dentin-chip. 4. Calcium-hydroxide. 5. Injection or «spiral» filling. 6. Cements. 7. Pastes. 8. Plastics. 9. Calcium phosphate.

Question 5. Methods of root canal obturation with cold gutta-percha

Single gutta-percha point and sealer. With the tendency to preparation techniques of greater taper, gutta-percha points of matching taper may be used. These fit the prepared canal so well that some operators are using a single gutta-percha point and sealer. The only advantage of this technique is its simplicity. The disadvantage is that the majority of sealers are soluble. As the canal will not be fully filled in three dimensions, tissue fluids may leach out the sealer over time. The use of single gutta-percha point and sealer technique today is considered to be below the standard of care in contemporary endodontic practice.

Lateral compaction technique. The lateral compaction of cold gutta-percha points with sealer is the technique most commonly taught in dental schools and used by practitioners and has long been the standard against which other methods of canal obturation have been judged. The technique can be used in most clinical situations and provides length control during compaction. The procedure can be accomplished with any of the acceptable sealers.

Step-by-step procedure of lateral compaction:

1. The canal should be irrigated, cleaned and dried.

2. A master point is selected and fitted to the canal. If cone is going beyond apical foramen, cut the cone to working length or use. It should be marked at working length, or grasped securely in endodontic locking tweezers larger number cone. Master cone selection is done by visual test, by tactile method, by radio-graphs (prefered).

3. The master point is coated with sealer and used to paste the canal walls with the sealer, using an in-out movement, before seating the point home into the canal at full working length.

4. A fine finger spreader is selected and the rubber stop set to working length. Place the spreader alongside the master point and compact using firm apical finger pressure only.

5. Leave the spreader in situ for 30 seconds. This is important as continuous pressure from the spreader is required to deform the gutta-percha point against the canal walls and to overcome its elasticity.

6. Select an accessory point with locking tweezers and dip its tip into sealer.

7. Immediately place the accessory point alongside the master point. Any delay will allow the master point to relax and the space will be lost. Reinsert the spreader and laterally compact both points.

8. Repeat the sequence using gradually larger spreaders and gutta-percha points until the canal is filled.

9. Remove excess gutta-percha from the canal orifice with a heated plugger or another heated instrument, and firmly compact the remaining

gutta-percha to seal the coronal access to the canal. If post-space preparation is required; it may be carried out at this stage. If not, a layer of resin-modified glass ionomer cement should be applied over the gutta-percha and the floor of the access cavity, completing the coronal seal. A periapical radiograph should be taken on completion, using a long-cone parallel technique.

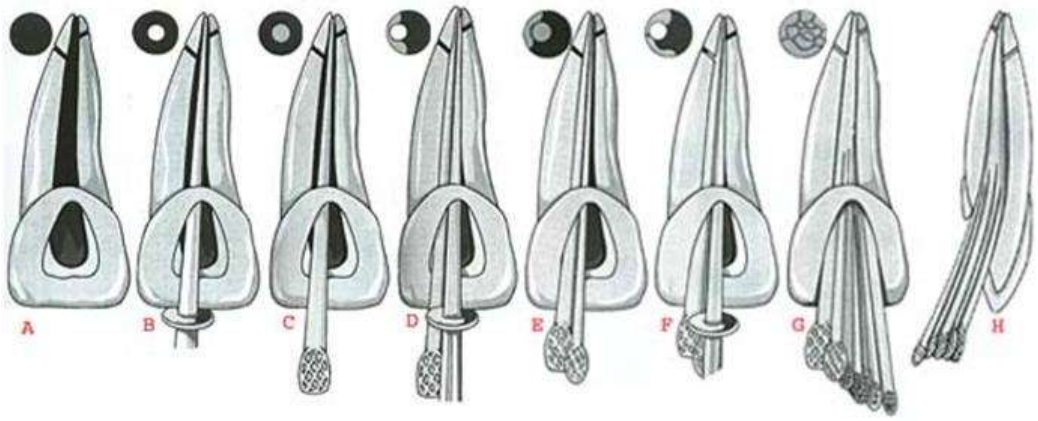


Figure 75. Lateral compaction of gutta-percha

Advantages of lateral compaction technique:

1. Can be used in most clinical situations.
2. During compaction of gutta-percha, it provides length control, thus decreases the chances of overfilling.

Disadvantages of lateral compaction technique:

1. May not fill the canal irregularities efficiently.
2. Does not produce homogenous mass.
3. Space may exist between accessory and master cones. It is considered that the space between each of the cones is filled with sealer.

Gutta flow is eugenol free radiopaque form which can be injected into root canals using an injectable system. It is a self-polymerizing filling system in which gutta-percha in powder form is combined with a resin sealer in one capsule.

Composition. Gutta flow consists of polydimethyl silloxan matrix filled with powdered gutta-percha, silicon oil, paraffin oil, palatinum, zirconium dioxide and nano silver.

Advantages:

1. Easy to use.
2. Time saving.
3. Does not require compaction.
4. Does not require heating.
5. Biocompatible.
6. Can be easily removed for retreatment.

Figure 76. Gutta Flow

Question 6. Warm methods of root canal obturation with gutta-percha

Lateral compaction of warm gutta-percha. A simple modification to the cold lateral compaction technique is to apply heat to gutta-percha. Heat can be applied to gutta-percha using:

1. A heat carrier.
2. An electrically heated tip.
3. An ultrasonic tip.

The softened material is easier to compact and will result in a denser root filling. Specially designed heat carriers should be used. The instruments illustrated in fig. 18 have a sharp tip for lateral compaction, and a blunt plugger tip for limited vertical compaction of the softened gutta-percha. Electrically heated spreaders are also available. It is important that the instruments are only gently warmed. If the spreader is too hot it will melt the gutta-percha, which will adhere to the instrument and be withdrawn from the canal.

Step-by-step procedure of warm lateral compaction:

1. Make space for a heated instrument with a cold spreader.
2. Place a heated spreader into the canal and laterally condense until cool. Remove the spreader cold (thereby allowing contraction and reducing the risk of removing the gutta-percha with the instrument).
3. Insert an accessory cone and sealer. Repeat the process until the canal is filled.

Warm lateral condensation has many advantages. Since it follows cold lateral condensation, heat is not introduced to the apex of the tooth. The technique also allows precise length control in the placement of gutta-percha and permits filling of voids, isthmuses, C-shaped canals, lateral and accessory canals, and internal resorptive areas. The potential for root fracture is reduced because the thermoplasticized gutta-percha mass flows easily into the anatomic variations with light spreader pressure. It is an easy technique to learn, and requires only a relatively inexpensive addition to the armamentarium. Warm lateral condensation does not require pre-heating or

special gutta-percha. In addition, cleaning and sterilization procedures are not complex.

Vertical compaction technique. Vertical compaction of warm gutta-percha method of filling the root canal was introduced by Schilder with an objective of filling all the portals of exit with maximum amount of gutta-percha and minimum amount of sealer. This is also known as Schilder's technique of obturation. In this technique using heated pluggers, pressure is applied in vertical direction to heat softened gutta-percha which causes it to flow and fill the canal space. Vertical compaction of warm gutta-percha also known as Schilder's technique of obturation.

Table 30. **Main characteristics of vertical compaction technique**.

Basic requirements of a prepared canal to be filled by vertical compaction technique are:	1. Continuous tapering funnel shape from orifice to apex. 2. Apical opening to be as small as possible. 3. Decreasing the cross sectional diameter at every point apically and increasing at each point as canal is approached coronally.
Advantages	Excellent sealing of canal apically, laterally and obturation of lateral as well as accessory canals.
Disadvantages	1. Increased risk of vertical root fracture. 2. Overfilling of canals with gutta-percha or sealer from apex. 3. Time consuming.
Technique	1. Using heated pluggers, pressure is applied in vertical direction to softened the gutta-percha and make it flow. 2. Select a master cone. 3. Cone should fit in 1 to 2 mm of apical stop. 4. Confirm thefit radiographically. 5. Select the pluggers. 6. Dry the canal and apply sealer. 7. Cut coronal end of master cone at occlusal reference point. 8. With heated plugger force gutta-percha into canal. 9. When apical filling is done, obturate the remaining canal. 10. Use small segments of gutta-percha, carry into canal and compact as described above.

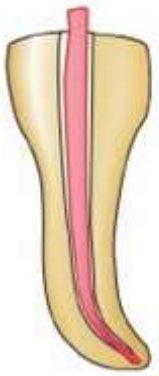


Figure77. Select the master gutta-percha cone

Figure78. Select the plugger according to canal shape andsize

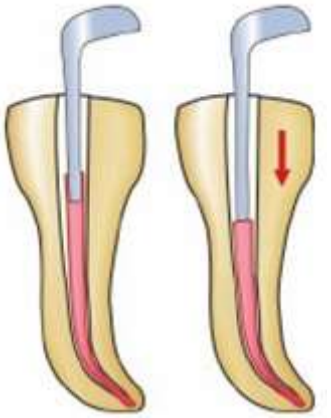


Figure 79. Heated plugger used to compact gutta-percha

Lateral/vertical compaction of warm gutta-percha. Vertical compaction causes dense obturation of the root canal, while lateral compaction provides length control and satisfactory ease and speed.

Advantages of both of these techniques are provided by a newer device, viz. Endotec II which helps the clinician to employ length control with warm gutta-percha technique. It comes with battery which provides energy to heat the attached plugger and spreader.

Technique:

1. Adapt master gutta-percha cone in canal.
2. Select Endotec plugger and activate the device.
3. Insert the heated plugger in canal beside master cone to be within 3 to 4 mm of the apex using light apical pressure.
4. Afterwards unheated spreader can be placed in the canal to create more space for accessory cones. This process is continued until canal is filled.

Advantages:

- Three dimensional obturation of canal.
- Better sealing of accessory and lateral canals.
- Endotec can also be used to soften and remove the gutta-percha.

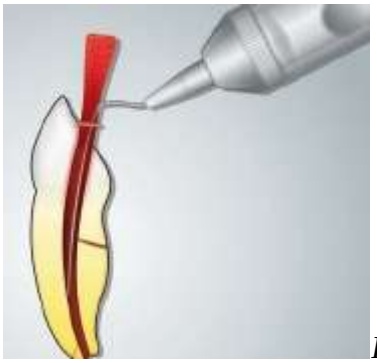


Figure 80. Obturation with Endotech device

Question 7. Solid carrier obturation technique - Thermafil

In 1978, Johnson described a unique yet simple method of canal obturation with thermoplasticized alpha-phase gutta-percha carried into the canal on an endodontic file. What was a curiosity in 1978 has become today a popular and respected technique of canal obturation.

Thermafil is considered the major core-carrier technique, and through a licensing agreement with Dentsply, a duplicate product, Densfil was created. Recently, two similar products were introduced: Soft-Core, and its European version, Three Dee GP. Thermafil (Dentsply/Tulsa) is a patented endodontic obturator consisting of a flexible central carrier, sized and tapered to match variable tapered files (.04/.06) endodontic files. The central carrier is uniformly coated with a layer of refined and tested alpha-phase gutta-percha. The use of the variable tapered files in canal preparation has enhanced the fit, placement, movement, and compaction of the gutta-percha delivered by the Thermafil core carrier. Likewise, the Thermafil system now comes with metallic size verifiers that are used to determine, with greater precision, the size and shape of the prepared canal prior to choosing the correct Thermafil carrier. Initially, the central carrier was a newly designed stainless steel device. Contemporary carriers are made of radiopaque plastic that is grooved along 60 degrees of their circumference.

Technique

1. Select a Thermafil obturator of the size and shape which fits passively at the working length. Verify the length of verifier by taking a radiograph.
2. Now disinfect the obturator in 5.25 percent sodium hypochlorite for one minute and then rinse it in 70 percent alcohol.
3. Preheat the obturator in “Thermaprep" oven for sometimes. This oven is recommended for heating obturator because it offers a stable heat source with more control and uniformity for plasticizing the gutta percha.
4. Dry the canal and lightly coat it with sealer. Place the heated obturator into the canal with a firm apical pressure to the marked working length.
5. Working time is 8 to 10 seconds after removal of obturator from oven. If more obturators are required, insert them immediately.
6. Verify the fit of obturation in radiograph. When found accurate, while stabilizing the carrier with index finger, sever the shaft level with the orifice using a prepi bur or an inverted cone bur in high speed handpiece.
7. Do not use flame heated instrument to sever the plastic shaft because instrument cools too rapidly and thus may cause inadvertent obturator displacement from the canal.
8. Now use a small condenser coated with vaseline or dipped in alcohol, to condense gutta-percha vertically around the shaft.

9. When the use of post is indicated, severe the obturator with the fissure bur at the selected length and give counter clockwise rotation of shaft following insertion to disengage the instrument.

Advantages

1. Requires less chair side time.
2. Provides dense three dimensional obturation as gutta-percha flows into canal irregularities such as fins, anastomoses, and lateral canals, etc.
3. No need to precurve obturators because of exible carriers.
4. Since this technique requires minimum compaction, so less strain while obturation with this technique.

Tests to the topic

1. Objectives of root canal obturation are

a. Total debridement of the pulpal space.
b. Development of a fluid tight seal at the apical foramen.
c. Total obliteration of root canal.
d. All answers are right.

2. Features of an ideal root canal obturation are:

a. Radiographically, filling should be seen 0.5 to 0.75 mm from radiographic apex.
b. Radiographically, filling should be seen 1 to 2 mm from radiographic apex.
c. Three dimensional obturation close to CDJ.
d. All answers are right.

3. What are requirements for an ideal root canal filling material?

a. Easily introduced into a root canal.
b. Seal the canal laterally as well as apically.
c. Not shrink after being inserted.
d. All answers are right.

4. What are the forms of gutta-percha?

a. α
b. β+
c. ϭ
d. Ɣ
e. All answers are right.

5. According to grossman classification sealers are divided into:

a. Zinc oxide resin cements.
b. Calcium hydroxide cements.

c. Paraformaldehyde cements.
d. Pastes.
e. All answers are right.

6. According to clark classification sealers are divided into:

a. Absorbable.
b. Non-absorbable.
c. All answers are right.

7. Advantages of znoe-based sealers are:

a. Easy to manipulate.
b. Radiopaque.
c. Ample working time.
d. Irritant to periapex.
e. Not easily absorbed from the apical tissues.
f. All answers are right.

8. According to grossman methods of root canal obturation are divided into:

a. Lateral condensation method.
b. Vertical condensation method.
c. Chemically plasticized gutta.
d. Injection techniques of obturating canals.
e. All answers are right.

9. According to stock methods of root canal obturation are divided into:

a. Sectional.
b. Single cone.
c. Multiple cone.
d. All answers are right.

10. Indicate advantages of lateral/vertical compaction of warm gutta-percha:

a. Three dimensional obturation of canal.
b. Better sealing of accessory and lateral canals.
c. Endotec can also be used to soften and remove the gutta-percha.
d. All answers are right.

LESSON 16. EVALUATION OF SUCCESS OF ENDODONTIC TREATMENT

Questions to be studied at the classes

1. Evaluation of success of endodontic treatment.
2. Causes of the endodontic failures
3. Different procedural accidents.
4. Factors Responsible for Endodontic Failures
5. Prevention methods of endodontic failures.
6. Different approaches to retreatment and repair of endodontic failures.

Question 1. Evaluation of success of endodontic treatment

Clinical Evaluation. Presence of symptoms though indicates the presence of pathology, but absence of a pain or any other symptoms does not confirm the absence of a disease. A little correlation exists between the presence of symptoms and the periapical disease.

Clinical criteria for success

1. No tenderness to percussion or palpation
2. Normal tooth mobility
3. No evidence of subjective discomfort
4. Tooth having normal form, function and esthetics
5. No sign of infection or swelling
6. No sinus tract or integrated periodontal disease
7. Minimal to no scarring or discoloration.

Radiographic Evaluation. The radiographic criteria for failures are development of radiographic periapical areas of rarefaction after the endodontics treatment, in cases where they were not present before the treatment or persistence or increase in sizes of the radiolucency after the treatment. To predict the success or failure, one should be able to accurately compare the radiographs that are taken at different times.

Prognosis is prediction of whether an endodontic treatment will be successful or a failure and if successful to what degree it will be. Normally, the development of apical periodontitis is indication of endodontic failures. This condition is frequently asymptomatic clinically, and the radiograph is the way to determine the success here.

Histological Evaluation. Histological criteria for success or failure of endodontic therapy may include absence of inflammation and regeneration of periodontal ligament, bone and cementum following endodontics therapy. Histologically, the success of endodontically treated tooth is reduced because chronic inflammation may persist for long even without any symptoms.

Histological criteria for success

- Absence of inflammation

- Regeneration of periodontal ligament fibers
- Presence of osseous repair
- Repair of cementum
- Absence of resorption
- Repair of previously resorbed areas.

Question 2. Causes of the endodontic failures.

Most commonly the causes of root canal failures are directly or indirectly related to bacteria somewhere in the root canal system. The treatment failures can occur despite of the strict adherence to the basic treatment principles. Multitude of factors affect the success or failure of the endodontic treatment but there are certain factors which are common in all the cases for their success or failure and in some cases, success or failure is particularity related to that individual case.

Factors affecting success or failure of endodontic therapy in every case

1. Diagnosis and the treatment planning
2. Radiographic interpretation
3. Anatomy of the tooth and root canal system
4. Debridement of the root canal space
5. Asepsis of treatment regimen
6. Quality and extent of apical seal
7. Quality of post endodontic restoration
8. Systemic health of the patient
9. Skill of the operator.

Basically the causes of root canal failures can be broadly divided into local and systemic.

Local Factors Causing Endodontic Failures

Infection. Presence of infected and necrotic pulp tissue in root canal acts as the main irritant to the periapical tissues. For success of the endodontic therapy, thorough debridement of the root canal system is required for removal of these irritants. If infected tissue is present, the host parasite relationship, virulence of microorganisms and ability of infected tissues to heal in the presence of microorganisms are the main factors which influence the repair of the periapical tissues following endodontic therapy.

If apical seal or coronal restorations are not optimal, reinfection of root canal can occur through them.

Incomplete Debridement of the Root Canal System. It is one of the principle factors contributing to the endodontics failures. The main objective of root canal therapy is the complete elimination of the microorganisms and their byproducts from the root canal system. The poor debridement can lead to residual microorganisms, their byproducts and tissue debris which further recolonize and contribute to endodontic failure. Presence of infected pulp

acts as main irritant to periapical tissues. Defective root canal obturation results in endodontic failure.

Excessive Hemorrhage. Extirpation of pulp and instrumentation beyond periapical tissues lead to excessive hemorrhage. Mild inflammation is produced because of local accumulation of the blood. The extravasated blood cells and fluids must be resorbed because otherwise they act as foreign body. Also the extravasated blood acts as nidus for bacterial growth especially in the presence of infection.

Overinstrumentation. Instrumentation beyond apical foramen causes decrease in the prognosis of endodontic treatment because of trauma to periodontal ligament and the alveolar bone . Whereas when instrumentation of the root canal system remains within the confines of root canals, the chances of success of endodontic therapy are more.

Chemical irritants in form of intracanal medicaments, irrigating solution decrease the prognosis of endodontic therapy if they get extruded in the periapical tissues. The complete biomechanical preparation of the root canal system does not require the use of these medicaments except in some cases where the chronic inflammation is present. One should take care while using the medicaments to avoid their periapical extrusion.

Iatrogenic Errors. Instrument separation: Instrument separation is caused by improper or overuse of instruments and forcing them in curved and tortuous canals. Basically separated instruments impair the mechanical instrumentation of infected root canals apical to instrument, which contribute to endodontic failure

Question 3. Different procedural accidents

It is possible to categorize the procedural errors as following:

1. Inadequately cleaned and shaped root canal system.
    a. Loss of working length
    b. Canal blockage
    c. Ledging of canal
    d. Missed canals
2. Instrument separation
3. Deviation from normal canal anatomy
    a. Zipping
    b. Stripping or lateral wall perforation
    c. Canal transportation
4. Inadequate canal preparation
    a. Overinstrumentation
    b. Overpreparation
    c. Under preparation
5. Perforations

a. Coronal perforations
b. Root perforations
- Cervical canal perforations
- Mid root perforations
- Apical perforations

c. Post space perforations

6. Obturation related
   a. Over obturation
   b. Under obturation
7. Vertical root fracture
8. Instrument aspiration

Inadequately cleaned and shaped root canal system. Regardless of the instrumentation technique used for cleaning and shaping of the root canal system, the main objectives of biomechanical preparation are to remove pulp tissue, debris and bacteria, as well as to shape the canal for obturation. As with access opening preparations, failure to pay close attention to detail during canal cleaning and shaping will result in violation of the principles of biomechanical canal preparation. These procedural errors and their sequelae can adversely affect the prognosis of treatment. The errors that most often occur during canal preparation include:

1. Loss of working length
2. Deviations from normal canal anatomy
3. Inadequate canal preparation
4. Perforations

Loss of working length during cleaning and shaping is a common procedural error. The problem may be noted only on the master cone radiograph or when the master apical file is short of established working length.

Etiology

- Secondary to other endodontic procedural errors, like blockages, formation of ledges and fractured instruments.
- Rapid increase in the file size.
- Accumulation of dentinal debris in the apical third of the canal. Preventive measures include frequent irrigation with NaOCl, recapitulation and periodic radiographic verification of working length.
- Lack of attention to details, such as malpositioned instrument stops, variations in reference points, poor radiographic technique and improper use of instruments.

To maintain proper working length during canal cleaning and shaping, adherence to the following specific guidelines is recommended:

1. Use sound and reproducible reference points.
2. Precurve all instruments

3. Continually observe the instrument stops as they approach the reference points.

4. Directional instrument stops should be used. The direction of the stop must be constantly observed.

5. When verifying the instrument position radiographically, use consistent radiographic angles.

6. Always maintain the original preoperative shape of the canal and clean and shape within these confines.

7. Use copious irrigation and recapitulation throughout cleaning and shaping procedures.

8. Always use sequential file sizes and do not skip sizes.

Complete cleaning and shaping of Master apical file short of working length root canal system

Recapitulation. Accumulation of dentinal debris in apicalthird because of loss of working length.

Canal blockage. A blockage is obstruction in a previously patent canal system that prevents access to the apical constriction or apical stop.

Etiology

1. Common causes of canal blockage can be packed dentinal chips, tissue debris, cotton pellets restorative materials or presence of fractured instruments.
2. The instrument does not reach to its full working length if it experiences any kind of restriction during its way to canal apex or if tip of the instrument used is wider than the canal diameter.
3. Blockage is confirmed by taking radiograph which may show that file is not reaching up to its established working length.

Reasons why file does not reach to full working length

(A) Dentin chips
(B) Wrong angulation of instrument
(C) Larger instrument than canal diameter
(D) Restriction to instrument making it short of apex

Ledging. Ledge is an internal transportation of the canal which prevents positioning of an instrument to the apex in an otherwise patent canal.

Etiology

- Caused by forcing uncurved instruments apically short of working length in a curved canal.
- Rotating the file at the working length causes deviation from the natural canal pathway, straightening of the canal, and the creation of a ledge in the dentinal wall.
- Rapid advancement in file sizes or skipping file sizes.

Identification of ledge formation. Ledges occur on the outer wall of the canal curvature. One may get suspicious that ledge has been formed when there is:

- Loss of tactile sensation at the tip of the instrument
- Loose feeling instead of binding at the apex.
- Instrument can no longer reach its estimated working length.
- When in doubt a radiograph of the tooth with the instrument in place is taken to provide additional information.

Ledge formation in a curved Ledge formation due to use of straight files in curved canal canal using stiffer files. Formation of ledge by use of stiff instrument in curved canal. B. Correction of ledge. Ledge is bypassed by making a small bend at tip of instrument. Bent instrument is passed along canal wall to locate original canal.

Missed canal. Sometimes endodontic failure can occur because of untreated missed canals which are store house of tissue, bacteria and other irritants. To avoid occurrence of such problem, one should have thorough knowledge of the root canal anatomy.

Etiology

1. Lack of thorough knowledge of root canal anatomy along with its variations.
2. Inadequate access cavity preparation.

Common Sites for Missed Canals

1. During canal exploration, if canal is not centered in the root, one should look for presence of extra canal.
2. There are several teeth which have predisposition for extra canal which might be missed if not explored accurately while treatment.

For example:

Maxillary premolars may have three canals (mesiobuccal, distobuccal and palatal):

- Upper first molars usually have four canals
- Mandibular incisors usually have extra canal
- Mandibular premolars often have complex root anatomy
- Mandibular molars may have extra mesial and/or distal canal in some cases.

Missed Canals can be located by

1. Taking radiographs.
2. Use of magnifying glasses, endomicroscope.
3. Accurate access cavity preparation.
4. Use of ultrasonics.
5. Use of dyes such as methylene blue.

6. Use of sodium hypochlorite: After thorough cleaning and shaping, pul chamber is filled with sodium hypochlorite. If bubbles appear in, it indicates either there is residual tissue present in a missed canal or residual chelator in the prepared canal.

Radiograph showing missed canal in maxillary second premolar.

Zipping is defined as transposition of the apical portion of the canal.

Etiology

This is commonly seen in curved canals because of following reasons:

1. Failure to precurve the files.
2. Forcing instruments in curved canal
3. Use of large, stiff instruments to bore out a curve canal.

In zipping, apical foramen tends to become a tear drop shape or elliptical, is transported from the curve of the canal.

File placed in curved canal cuts more on the outer portion of the canal wall at its apical extent, thus causing movement of the canal away from the curve and its natural path. In contrast, the coronal third of the flutes remove more on the inner most aspect of the canal wall causing an uneven reduction of the dentin in the coronal third.

When a file is rotated in a curved canal, a biomechanical defect known as an elbow is formed coronal to the elliptically shaped apical seat. This is the narrowest portion of the canal. In many cases the obturating material terminates at the elbow leaving an unfilled zipped canal apical to elbow. This is the common occurrence with laterally compacted gutta-percha technique. Use of vertical compaction of warm gutta-percha or thermoplasticized gutta-percha is ideal in these cases to compact a solid core material into the apical preparation without using excessive amount of sealer.

Elbow prevents optimal compaction in the apical portion of the canal. Since elbow becomes the apical seat, the obturating material is compacted against the elbow and patient is recalled or regular basis.

Zipping is transposition of apical portion of the canal Elbow formed in a curved canal.

Stripping or lateral wall perforation. “Stripping” is a lateral perforation caused by over instrumentation through a thin wall in the root and is most likely to happen on the inside or concave wall of a curved canal such as distal wall of mesial roots in mandibular first molars. Stripping is easily detected by sudden appearance of hemorrhage in a previously dry canal or by a sudden complaint by patient. Strip perforation occurs more commonly on inner side of curve

Instrument separation. Instrument breakage is a common and frustrating problem in endodontic treatment which occurs by improper or

overuse of instruments. Any time during the cleaning and shaping of root canal file, reamer, broach or Gates Glidden may break especially while working in curved, narrow or tortuous canals.

Etiology

• Variation from normal root canal anatomy.
• Overuse of damaged instruments.
• Overused of dull instruments.
• Inadequate irrigation.
• Use of excessive pressure while inserting in canal.
• Inadaquate access cavity preparation.

Curved, narrow and tortuous canals are diameter, curvature of canal and location of instrument affects its removal more prone for instrument fracture.

Prognosis of separated instrument depends upon following factors:

a. Timing of separation
b. Status of pulp tissue
c. Position of separated instrument
d. Ability to retrieve or bypass the instrument.

Overpreparation is excessive removal of tooth structure in mesiodistal and buccolingual direction. During biomechanical preparation of the canal, size of apical preparation should correspond to size, shape and curvature of the root. For example, to produce an apical seat equivalent to No. 50 K–file in a curved (10°-20°) mesiobuccal canal of a mandibular first molar is likely to cause procedural errors like zipping of root apex, perforation and transportation of the apical foramen. Adherence to the guidelines for the recommended range of size termination for each type of root is mandatory, with modification made as necessary.

Suggested size for final apical preparation

Table. 31. **Tooth group Final apical size**

Maxillary teeth	Central incisor 35 to 60 Lateral incisor 25 to 40 Canine 30 to 50 Premolar 25 to 40 Molar MB/DB 25 to 40 Palatal 25 to 50
Mandibular teeth	Incisors 25 to 40 Canines 30 to 50 Premolar 30 to 50 MolarMB/ML 25 to 40 Distal 25 to 50

Over preparation is a commonly seen in the apical portion of the canal system, but it can also occur in middle and coronal portion of the canal. Excessive canal flaring increases the chances of stripping and perforation. One should avoid excessive removal of tooth structure because over prepared canals are potentially weaker and subject to fracture during compaction and restorative procedures.

Overpreparation of canal causes excessive removal of root dentin. Overpreparation increases the chances of strip perforation (arrow) especially on inner side of a curved canal

Underpreparation is the failure to remove pulp tissue, dentinal debris and microorganisms from the root canal system. Sometimes the canal system is improperly shaped which prevents three dimensional obturation of the root canal space.

Etiology

Inadequate preparation of the canal system occurs in the following ways.

1. Insufficient preparation of the apical dentin matrix.
2. Insufficient use of irrigants to dissolve tissues and debris.
3. Inadequate canal shaping, which prevents depth of spreader or plugger penetration during compaction.
4. Establishing the working length short of the apical constriction.
5. Creation of ledges and blockages that prevent complete cleaning and shaping. Underprepared canals are best managed by strictly following the principles of working length determination and biomechanical preparation. Copious irrigation and recapitulation during instrumentation ensure a properly cleaned canal. Before obturation spreaders and pluggers must be pre-fitted to determine their depth of placement and to ensure proper canal shape.

Perforations. According to glossary of endodontic terms (by AAE) the perforation is defined as “the mechanical or pathological communication between the root canal system and the external tooth surface”.

Pathologic conditions such as caries, root resorptions aside, the mechanical or iatrogenic perforation are the procedural mishaps which can significantly affect the long term prognosis of a tooth. Perforations can occur at any stage while performing endodontic therapy that is during access cavity preparation or during instrumentation procedures leading to canal perforations at cervical, mid-root or apical levels.

Access cavity perforation can occur during access cavity preparation. If the perforation is above the periodontal attachment, leakage of saliva into cavity or sodium hypochlorite in mouth are the main sign. But if perforation occurs into the periodontal ligament, bleeding is the hallmark feature.

Root canal perforation can occur at three levels:

a. Cervical canal perforation: It commonly occurs while locating the canal orifice and flaring of the coronal third of the root canal. Sudden appearance of blood from canal is the first sign of perforation.

Perforation caused by misdirection of bur during access cavity preparation of a molar with previously placed crown. Misorientation of bur causing perforation during access cavity preparation.

b. Mid-root perforation: It commonly occurs in the curved canal when a ledge is formed during instrumentation along inside the curvature of root canal, as it is straightened out, i.e. strip perforation may result. Usually it is caused by over-instrumentation and over- preparation of the thin wall of root or concave side of the curved canals. Sudden appearance of bleeding is the pathognomic feature.

c. Apical root perforation: Apical root perforation can occur.

I. When instrument goes into periradicular tissue, i.e. beyond the confines of the root canal.

II. By overuse of chelating agents along with straight and stiffer large sized instruments to negotiate ledging, canal blockage or zipping, etc.

Occurrence of a perforation can be recognized by:

1. Placing an instrument into the opening and taking a radiograph.
2. Using paper point.
3. Sudden appearance of bleeding.
4. Complain of pain by patient when instrument touches periodontal tissue.

Vertical root fracture can occur at any phase of root canal treatment that is during biochemical preparation, obturation or during post placement. This fracture results from wedging forces within the canal. These excessive forces exceed the binding strength of existing dentin causing fatigue and fracture

Clinical Features

1. Vertical root fracture commonly occurs in faciolingual plane.
2. Sudden crunching sound accompanied by pain is the pathognomic of the root fracture.
3. The fracture begins along the canal wall and grows outwards to the root surface.
4. Certain root shapes and sizes are more susceptible to vertical root fracture, for example, roots which are deep facially and lingually but narrow mesially and distally are particularly prone to fracture.
5. The susceptibility of root fracture increases by excessive dentin removal during canal preparation or post space preparation. Also the excessive

condensation forces during compaction of gutta-percha while obturation increases the frequency of root fractures.

6. Radiographically vertical root fracture may vary from no significant changes to extensive resorption patterns. In chronic cases, they may show hanging drop radiolucent appearance. According to Cohen, it can be seen radiographically as 'J' shaped radiolucency or may appear as halo shaped defect around the involved root.

Instruments aspiration. Aspiration of instruments can occur during endodontic therapy if accidentally dropped in the mouth. It occurs specially in absence of rubber dam. It is a type of emergency which has to be tackled as soon as possible. Patient must be provided medical care for examination which includes radiograph of chest and abdomen.

High volume suction tips, hemostats or cotton pliers can be helpful only in some cases, when the objects are readily accessible in throat otherwise medical care is needed.

This accident can be prevented by:

1. Use of rubber dam.
2. Tying up the rubber dam clamp or endodontic instrument with floss.

Question 4. Factors Responsible for Endodontic Failures

Local	***Systemic***
Infection	Nutritional deficiencies
Incomplete debridement of the root canal system	Diabetes mellitus
Excessive hemorrhage	Renal failure
Overinstrumentation	Blood dyscrasias
Chemical irritants	Hormonal imbalance
Iatrogenic errors	Autoimmune disorders
– Separated instruments	Opportunistic infections
– Canal blockage and ledge	Aging
– Perforations	Patients on long-term steroid formation therap
– Incompletely filled teeth	
– Overfilling of root canals	
Corrosion of root canal fillings	
Anatomic factors	
Root fractures	
Traumatic occlusion	
Periodontal considerations	

Factors Affecting Prognosis of Endodontic Treatment

1. Presence of any periapical radiolucency

2. Quality of the obturation
3. Apical extension of the obturation material
4. Bacterial status of the canal
5. Observation period
6. Post-endodontic coronal restoration
7. Iatrogenic complication.

Question 5. Methods of prevention of endodontic failures.

Canal Blockage

Prevention

1. Remove all the caries, unsupported tooth structure, restorations before completion of the access cavity preparation.
2. Keep the pulp chamber filled with an irrigant during canal preparation
3. There should be a straight line access to the canal orifices
1. Straight line access to canal orifices
4. All temporary restorations around the outline of the access opening must be removed.
5. Copious irrigation must always be done during pulp space debridement and canal cleaning and shaping. Constant flushing and removal of debris reduces the amount of foreign material present in canal system.
6. Intracanal instruments must always be wiped clean before they are inserted into the canal system.
7. Instruments must be used in sequentially order.
8. Recapitulation must be done during instrumentation.
9. Excessive pressure and rotation of intracanal instruments must be avoided.
10. Never use instruments in a dry canal.
11. Place a sound temporary restoration.

Prevention of Ledge Formation

1. Use of stainless steel patency files to determine canal curvature.
2. Accurate evaluation of radiograph and tooth anatomy.
3. Precurving of instruments for curved canals.
4. Use of flexible NiTi files.
5. Use of safe ended instruments with non cutting tips.
6. Use of sequential filing avoid skipping instruments sizes.
7. Frequently irrigation and recapitulation during biomechanical preparation.
8. Preparation of canals in small increments.

Prevention of Missed Canal

1. Good radiographs taken at different horizontal angulations.
2. Good illumination and magnification.
3. Adequate access cavity preparation

4. Clinician should always look for an additional canal in every tooth being treated.

Significance of Missed Canal. Missed canal can contribute to endodontic failure because it holds the tissue debris, bacteria and other irritants. The tooth should be retreated first conservatively if endodontic failure exists, before going for endodontic surgery procedure.

Zipping can be prevented by:

1. Using precurved files for curved canals.
2. Using incremental filing technique.
3. Using flexible files.
4. Removing flutes of file at certain areas, for example, file portion which makes contact with outer dentinal wall at the apex and portion which makes contact with inner dentinal wall especially in the mid root area.
5. Over curving in apical part of the file specially when working for severely curved canals.

Prevention of Lateral Wall Perforation

1. Use of pre-curved files for curved canals.

2. Use of modified files for curved canals. A file can be modified by removing flutes of file at certain areas, for example, file portion which makes contact with outer dentinal wall at the apex and portion which makes contact with inner dentinal wall especially in the mid-root area

3. Using anticurvature filing, i.e. more filling pressure is placed on tooth structure away from the direction of root curvature and away from the invagination, thereby preventing root thinning and perforation of the root structure.

Anticurvature filing.

Prevention of Instrument Separation

1. Examine each instrument before placing it into the canal.

One should always discard instrument when there is:

- Bending of instrument.
- Corrosion of instrument
- Unwinding of flutes.
- Excessively heating of instrument
- Dulling of NiTi instrument

2. Instead of using carbon steel, use stainless steel files.
3. Use smaller number of instruments only once.
4. Always use the instruments in sequential order.
5. Never force the instrument into the canal.
6. Canals should be copiously irrigated during cleaning and shaping procedure.
7. Never use instruments in dry canals.

8. Always clean the instrument before placing it into the canal.

Debris collected between the flutes retard the cutting efficiency and increase the frictional torque between the instrument and canal wall.

9. Do not give excessive rotation to instrument while working with it.

Prevention of root fracture basically involves avoidance of the causes of root fracture. The main principles to prevent root fracture are to:

1. Avoid weakening of the canal wall.
2. Minimize the internal wedging forces.

To avoid occurrence of vertical root fracture:

1. Avoid over preparation of the canal.
2. Use less tapered and more flexible compacting instruments to control condensation forces while obturation.
3. Posts should not be used unless they are necessary to retain a tooth.

Question 6. Different approaches to retreatment and repair of endodontic failures.

Treatmentof Canal Blockage

- When a blockage occurs, place a small amount of EDTA lubricant on a fine instrument and introduce into the canal.

Use a gentle watch winding motion along with copious irrigation of the canal to remove the dentin chips or tissue debris.

One should avoid giving the excessive rotation to the instrument as it may cause instrument separation.

- If this doesn't solve the problem, endosonics may be used to dislodge the dentin chips by the action of acoustic streaming.
- Whatever happens don't force the instrument into the blockage as it may further pack the dentinal debris and worsen the condition. Moreover, forcing instruments may cause the perforation of the canal. In some cases, canal can be obturated to the blockage level such as if patient is asymptomatic with no associated endodontic or periodontal problem.

Treatment of Ledge Formation. To negotiate a ledge, choose a smaller number file, usually No. 10 or 15. Give a small bend at the tip of the instrument and penetrate the file carefully into the canal. Once the tip of the file is apical to the ledge, it is moved in and out of the canal utilizing ultra short push-pull movements with emphasis on staying apical to the defect. When the file moves freely, it may be turned clockwise upon withdrawal to rasp, reduce, smooth or eliminate the ledge. When the ledge can be predictably bypassed, then efforts are directed towards establishing the apical patency with a No. 10 file. Gently passing 0.02 tapered No. 10 file 1 mm through the foramen ensures its diameter is at least 0.12 mm and makes the way for the No. 15 file. Nowadays, a significant improvement has occurred in ledge management by use of nickel-titanium (NiTi) hand files that exhibit

tapers greater than ISO files. Progressively tapered NiTi files can be introduced into the canal when the ledge has been bypassed, the canal negotiated and patency established.

Not all ledges can be removed. Clinicians must weigh risk versus benefit and make every effort to retain maximum amount of remaining dentin.

Management of Lateral Wall Perforation. Successful repair of a stripping or perforation relies on the adequacy of the seal established by repair material. Access to mid-root perforation is most often difficult and repair is not predicTable Calcium hydroxide can be used as a biological barrier against which filling material is packed. Repair of strip perforation can be done both non-surgically as well as surgically. Majority of techniques however proposed a two step method, where the root canal is first obturated and defect is repaired surgically.

Management of Instrument Separation. Always inform the patient immediately. Take a radiograph so as to check the site of fractured instrument.

Instrument Retrieval. Before instrument retrieval one should evaluate the tooth radiographically to check:

1. Curvature and length of canal
2. Accessibility of instrument
3. Location of separated instrument
4. Type of broken instrument that is whether stainless steel or NiTi
5. Amount of dentin present around the instrument.

One should make use the combination of ultrasonics, adequate magnification and illumination for instrument retrieval. Special instruments used for retrieval of separated instrument are:

1. Wire-loop technique
2. Masserann kit
3. Endoextractor
4. Instrument removal system
5. Separated instrument retrieval

Repair of the Perforation. Treatment of the endodontics perforation depends on recognition of the condition, location, size, level of the perforation, timing of therapeutic intervention and clinician's skill and experience. Prognosis of endodontically treated teeth with perforation depends upon prevention of bacterial infection of the perforation site.

Location greatly influences the prognosis. When perforation is located at alveolar crest or coronal to it, prognosis is poor because of epithelial migration and periodontal pocket formation. Perforation in the furcation area has the poor prognosis.

Perforation in coronal third of root and surrounded by a healthy periodontium, i.e. which does not communicate with the gingival sulcus has good prognosis. Perforation occurring in mid-root and apical part of root does not have communication with oral cavity and thus has good prognosis.

Size of perforation too affects the prognosis. A small perforation has less tissue destruction and inflammation, thus having better prognosis than larger sized perforation.

Visibility, accessibility also affects the perforation repair.

Time between perforation repair affects the prognosis greatly. The perforation should be repaired as soon as possible to discourage further loss of attachment and prevent sulcular breakdown. Early treatment enhances the success.

Associated periodontal conditionand strategic importance of tooth also influence the treatment plan of the perforation. If attachment apparatus is intact without pocketformation, nonsurgical repair is recommended whereas in case of loss of attachment, surgical treatment should be planned. In addition esthetics influences the perforation repair and material to be used for repair of the perforation.

Material Used For Perforation Repair

Different materials have been tried for perforation repair since long with variable degree of the success.

An Ideal Material for Perforation Repair should

- Adhere to preparation walls of the cavity and seal the root canal system.
- Be non-toxic
- Be easy to handle
- Be radiopaque
- Be dimensionally stable
- Be well tolerated by periradicular tissue
- Be non-absorbable
- Not corrode
- Not be affected by moisture
- Not stain periradicular tissues.

Some of the most investigated materials for perforation repair include amalgam, calcium hydroxide, IRM, Super EBA, gutta-percha, MTA, other materials tried for repair include dentin chips, hydroxyapatite, glass ionomer cements and plaster of paris.

For perforation repair, hemostatics are needed to control the hemorrhage and make the area dry so that optimal placement of restorative material can be accomplished. Materials which can be used as hemostatics include calcium hydroxide, calcium sulphate, freezed dried bone and/or MTA. Whichever is the material used, the ultimate goal is to seal the defect

with a biocompatible material and maintain an intact periodontal attachment apparatus.

Treatment of vertical root fracture involves extraction in most of the cases. In multirooted teeth, root resection or hemisection can be tried. Other treatment options include retention of the fractured fragment and placement of calcium hydroxide or cementation of the fractured fragments. Recently, repair of root fracture have been tried by binding them with the help of adhesive resins, glass ionomers and lasers. But to date, no successful technique has been reported to correct this problem.

Tests to the topic

1. Can a pre-curved tool be inserted into the root canal?

a. Only H-file.
b. Only K-file.
c. Only Rimer.
d. Yes.

2. Is it necessary a moist in the root channel when working with machine tools?

a. Yes.
b. No.
c. Only when working with pro-files.
d. Only in narrow channels.

3. What is the optimal period for the radiographic control of a satisfactory or not satisfactory endodontic tooth treatment?

a. 0.5 years.
b. 1 year.
c. 2 years.
d. 3 years.
e. 4 years.

4. The final control photograph shows

a. The degree of sealing of the main canal in the apical direction.
b. The degree of filling of the main canal in the mezio-distal direction.
c. The degree of filling of the main canal in the mouth area.
d. All of the above.

5. What are different criteria's used for evaluation of endodontic treatment?

a. Clinical.
b. Radiographic.

c. All of the above.

6. What are the clinical criteria for used for evaluation of endodontic treatment?

a. No tenderness to percussion or palpation.
b. Normal tooth mobility.
c. No evidence of subjective discomfort.
d. Tooth having normal form, function and esthetics.
e. No sign of infection or swelling.
f. No sinus tract or integrated periodontal disease.
g. Minimal to no scarring or discoloration.
h. All of above.

7. Factors affecting success or failure of endodontic therapy

a. Diagnosis and the treatment planning.
b. Radiographic interpretation.
c. Anatomy of the tooth and root canal system.
d. Debridement of the root canal space.
e. Asepsis of treatment regimen.
f. Quality and extent of apical seal.
g. Quality of post endodontic restoration.
h. Systemic health of the patient.
i. Skill of the operator.
j. All of above.

8. What are European Channel Sealing Standard (European Society Of Endodontology, 2002)?

a. The entire canal system is sealed up to the physiological opening.
b. The sealed root canal has a conical shape, contentiously tapered towards the apex, preserves the original shape of the canal.
c. The root seal of a hardening or semi- hardening material in combination with a sealer without emptiness, has a tight contact with the walls of the channel.
d. On the control X-ray, the sealed root canal and periapical region are visible at a distance of at least 2 mm.
e. All of above.

9. What are the Radiographic Criteria for Success of Endodontic Treatment

a. Normal or slightly thickened periodontal ligament space.
b. Reduction or elimination of previous rarefaction.
c. No evidence of resorption.

d. Normal lamina dura.
e. A dense three-dimensional obturation of canal space.
f. All of above.

10. Before instrument retrieval one should evaluate the tooth radiographically to check:

a. Curvature and length of canal.
b. Accessibility of instrument.
c. Location of separated instrument.
d. Type of broken instrument that is whether stainless steel or NiTi.
e. Amount of dentin present around the instrument.
f. All of above.

Test answers

Questions									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Lesson 1									
e	b	b	b	b	b	b,c,e	a-c	e	e
Lesson 2									
a,c,d	a,c	e	a,b,d	a-c	f	d	d	a	a
Lesson 3									
a,c,d	d	a,c	e	c	c	c	a	c	a
Lesson 4									
a,b,d	e	a-c	a	e	a	d	e	e	b
Lesson 5									
a	a	a	b	a-c	d	g	g	e	f
Lesson 6									
a	a,e	a	c	b	b	a	b	a	a
Lesson 7									
c	a,b	c,d	e	c	b	a	i	i	c
Lesson 8									
d	c	g	a-c	f	e	c	a-c	a-b	d
Lesson 9									
f	i	e	c	a	a	a	h	a	b
Lesson 10									
g	g	f	f	g	e	i	h	d	f
Lesson 11									
g	a,b	d	e	a-c	a,c,d	d	d	a,c,d	a
Lesson 12									
d	e	c	a,b,c,f	a	c	a	d	a-c	a
Lesson 13									
d	a	a	a	b	a,c	e	b-d	a	a,b
Lesson 14									
e	c-e	c	c	e	c	f	a-d	a-c,e	a-c,e
Lesson 15									
d	a,c	d	a-b	e	c	a-c	e	d	d
Lesson 16									
d	a	a	d	c	h	j	e	f	f

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