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ROOT CANAL IRRIGANTS AND MEDICAMENTS

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МИНИСТЕРСТВО ЗДРАВООХРАНЕНИЯ РЕСПУБЛИКИ БЕЛАРУСЬ
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КОРНЕВЫЕ ИРРИГАНТЫ И ЛЕКАРСТВЕННЫЕ СРЕДСТВА

ROOT CANAL IRRIGANTS AND MEDICAMENTS

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Изложены базовые принципы медикаментозной дезинфекции корневых каналов зубов при эндодонтическом лечении, описаны основные растворы применяемых ирригантов, механизмы их действия, различные техники и протоколы антисептической обработки системы корневых каналов зуба, а также методы применения внутриканальных лечебных средств в стоматологии. Первое издание вышло в 2015 году.

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ROOT CANAL IRRIGATION

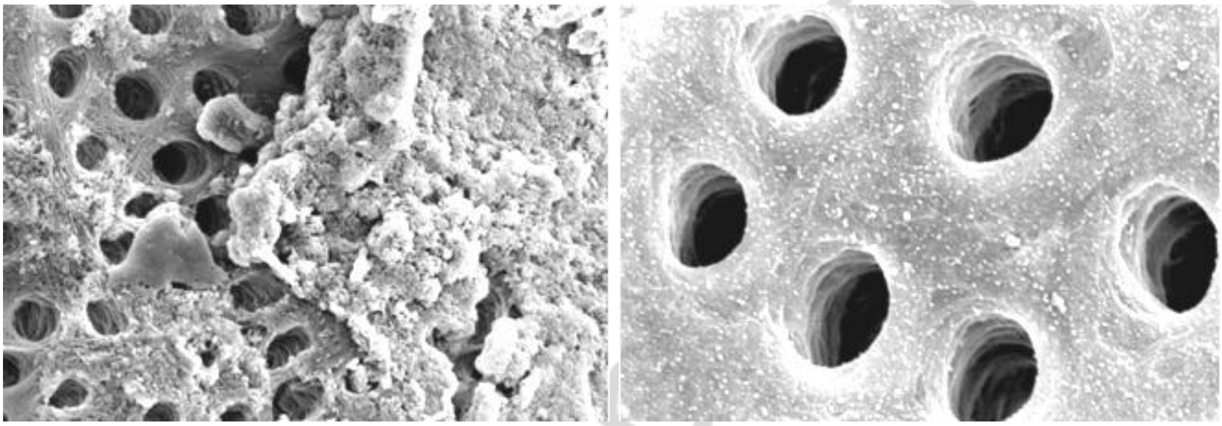
There can be no doubt today that microorganisms, either remaining in the root canal space after treatment or recolonizing the filled canal system, are the main cause of endodontic failure. Infection of the root canal space occurs most frequently as a sequel to a profound carious lesion. Cracks in the crown structure extending into the pulp chamber can also be identified as a cause of endodontic infection.

The objective of endodontic treatment is to prevent or eliminate infection within the root canal. Local wound debridement in the diseased pulp space is the main step in root canal treatment to prevent the tooth from being a source of infection. Over the years, research and clinical practices have concentrated on instrumentation, irrigation and medication of the root canal system followed by obturation and the placement of coronal seal.

The main purpose of instrumentation is the mechanical debridement of the root canal system and the creation of a space for delivery of antimicrobial substances. Furthermore, a well-shaped root canal system facilitates the proper placement of a tight root canal filling to prevent recolonization by oral microbiota. But every root canal system has spaces that cannot be cleaned mechanically (fig. 1). With both current nickel-titanium instrumentation systems and traditional stainless-steel hand instruments almost half of the root canal walls are left unprepared. Therefore, it is the irrigants that we rely on to clean and disinfect these anatomic complexities. *The only way we can clean webs, fins and anastomoses is through the effective use of an irrigation solution.*

Fig. 1. Complicated root canal anatomy

Irrigation is an important part of root canal treatment because it assists us in removing bacteria and debris, and configuring the system so that it can be obturated to eliminate dead space. During the past 20 years, endodontics has begun to appreciate critically the important role of irrigation in successful endodontic treatment. The purpose of endodontic irrigation is to remove debris created during instrumentation, and to dissolve and/or flush out inorganic and organic remnants of the pulp system, bacteria and bacterial byproducts that are not removed by mechanical instrumentation. With the introduction of obturation materials designed to bond with dentin, irrigation solutions must be used with consideration of the condition of the dentin surface that is most suitable for bonding. Figure 2 shows the dentin surface before and after preparation for bonding. Attempts to eliminate pulp space infection with instrumentation only, without the use of antimicrobial agents, have proven to be unsuccessful.



a ***b***

Fig. 2. Dentin surface before (*a*) and after preparation (*b*) for bonding

Modern root canal treatment requires to use both mechanical and chemical preparation and disinfection of the canal system. It's truly said, *"Instruments shape, irrigants clean"*.

It follows, the **main purposes of root canal irrigation:**

1) removal of vital and necrotic pulp tissue;

2) neutralization or removal of bacterial cells and their metabolic products remaining in the root canal system;

3) removal of the smear layer.

In order to get maximum efficiency from the irrigant, the latter must reach the apical portion of the canal. The choice of irrigants, their protocol and method of use can greatly influence the outcome of endodontic therapy.

An **"ideal irrigant solution"** must fulfill some criteria. It should:

1. Have a broad spectrum of antimicrobial properties.
2. Aid in the debridement of the canal system.
3. Have the ability to dissolve necrotic tissue or debris.
4. Have a low toxicity level.
5. Be a good lubricant.
6. Have low surface tension so that it can easily flow into inaccessible areas.

7. Be able to effectively sterilize the root canal (or at least disinfect them).

8. Be able to prevent formation of a smear layer during instrumentation or dissolve the latter, once it is formed.

9. Inactivate endotoxin.

10. Have little potential to cause an anaphylactic reaction.

11. Be easy to use.

12. Have an adequate shelf life and be easy to store.

Functions of irrigants:

1. Irrigants perform physical and biologic functions. Dentin shavings get removed from the canals by irrigation. Thus, they do not get packed at the apex of the root canal.

2. Instruments do not work properly in dry canals. Their efficiency increases through 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 which instruments cannot reach.

5. Most irrigants are germicidal but they also have antibacterial action.

6. Irrigants also have bleaching action to lighten teeth discoloured by trauma or extensive silver restorations.

7. Though presence of irrigants in the canal facilitates instrumentation, simultaneous use of some lubricating agents (RC prep, REDTAC, Glyde, etc.) makes the instrumentation easier and smoother.

Types of irrigation solutions. Countless solutions have been used for irrigation. These include inert solutions like Isotonic saline to highly caustic solutions like formaldehyde. We will only discuss the irrigants used currently.

The most common irrigants used today are:

1. Alkalis: sodium hypochlorite.

2. Chelating agents: ethylene diamine tetra acetic acid (EDTA), citric acid.

3. Antibacterial agents: chlorhexidine.

4. Oxidizing agents: hydrogen peroxide, carbamide peroxide.

SODIUM HYPOCHLORITE (NAOCL)

Sodium hypochlorite has been used as an endodontic irrigant since 1920. Today, it is the most popular and the most ideal primary irrigating solution. Of all the substances currently used, sodium hypochlorite is the most ideal, as it covers most of the requirements for endodontic irrigant than any other known compound. NaOCL has a unique capacity to dissolve organic tissue. It dissolves pulp, necrotic material and organic components of the smear layer. It has a broad spectrum of antibacterial activity and is an excellent lubricant. It is inexpensive, easily available and has a reasonably good shelf life. However, it is caustic to tissues and should be used with caution. Both patient and doctor should wear protective glasses.

Rubber dam should be used to prevent leaching into the patient's oral tissues. Forceful extrusion of NaOCL into the periapical region can cause a severe inflammatory reaction.

Mechanism of sodium hypochlorite action. At body temperature, reactive chlorine in aqueous solution exists in two forms: hypochlorite (OCl–) and hypochlorous acid (HOCl). The state of available chlorine depends on the solution pH; if it is above pH 7.6, it is mainly of hypochlorite form; if it is below this pH level, it is hypochlorous acid. Presence of 5 % free chlorine in sodium hypochlorite is responsible for breakdown of proteins into amino-groups. The pH of commonly used sodium hypochlorite is 12, at which the (OCl–) form exits. Hypochlorite dissolves necrotic tissue because of its high alkaline nature (pH 12).

> **Good to know!**
> *History of chlorine-releasing agents*
> Introduced by Dakin during World War I
> 1936, Walker — First suggested its use in root canal therapy
> 1941, Grossman — Used it as an intracanal medicament
> 1973, Spangberg — 0.5 percent NaOCl has a good germicidal activity
> 1977, Madden — Compared various concentrations of sodium hypochlorite

Concentration of sodium hypochlorite for endodontic use. There has been much controversy over the concentration of hypochlorite solutions to be used in endodontics. As Dakin's original 0.5 % sodium hypochlorite solution was designed to treat open (burning) wounds, it was surmised that in the confined area of a root canal system, higher concentrations should be used, as they would be more efficient than Dakin's solution. The antibacterial effectiveness and tissue-dissolution capacity of aqueous hypochlorite is a function of its concentration, but so is its toxicity. It appears that the majority of American practitioners use "full strength" 5.25 % sodium hypochlorite as it is sold in the form of household bleach. However, severe irritations have been reported when such concentrated solutions were inadvertently forced into the periapical tissues during irrigation, or leaked through the rubber dam. Furthermore, a 5.25 % solution significantly decreases the elastic modulus and flexural strength of human dentin compared to physiologic saline, while a 0.5 % solution does not. This is most likely because of the proteolytic action of concentrated hypochlorite on the collagen matrix of dentin. The reduction of intracanal microbiota, on the other hand, is not any greater when 5 % sodium hypochlorite is used as an irrigant as compared to 0.5 %. From in-vitro observations, it would appear that a 1 % NaOCl solution should suffice to dissolve the entire pulp tissue in the course of an endodontic treatment session. It must be realized that during irrigation, fresh hypochlorite consistently reaches the canal system, and concentration of the solution may thus not play a decisive role. Unclean areas may be a result of the inability of solutions to physically reach these areas rather than their concentration. Hence, based on the currently available evidence, there is no rationale for using hypochlorite solutions at concentrations over 3 %.

Methods increasing the efficacy of sodium hypochlorite (fig. 3).

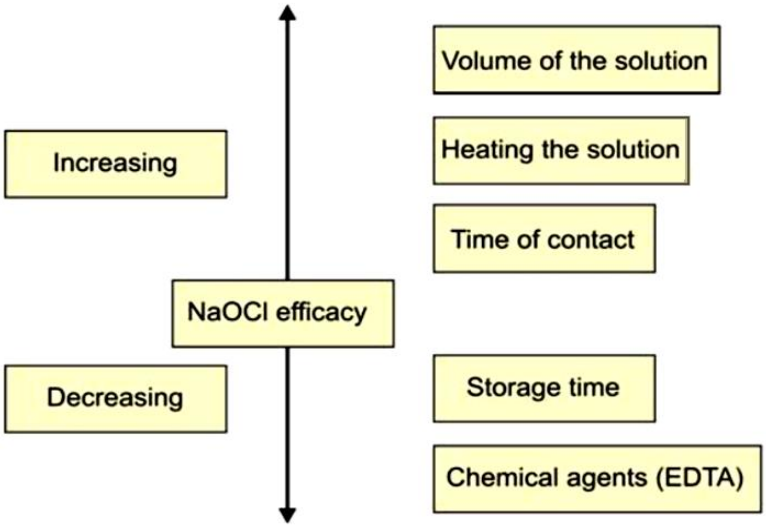


Fig. 3. Factors affecting the efficacy of sodium hypochlorite

Importance of time: it must be noted that very few studies or practitioners give importance to the time that is required for NaOCl to be effective. NaOCl needs at least 40 minutes to completely dissolve pulp tissue. Since antimicrobial effectiveness of sodium hypochlorite is directly related to its contact time with the canal, the greater the contact time, the more effective it is. This is especially important in necrotic cases. With current rotary Ni-Ti systems, the time taken to prepare a canal has decreased drastically. Therefore, many a time, NaOCl is not placed over an adequate period of time in the canal to be totally effective.

Heat: it has been shown that warming sodium hypochlorite to 30–40°, increases its tissue dissolving properties (fig. 4, 5). The optimum range of hypochlorite temperature for dissolving organics is from 21 °C to 40 °C. 37 °C is the optimal temperature level for the maximum bactericidal effect of NaOCl. But one should be careful not to overheat the solution because this can cause break-down of sodium hypochlorite constituents and thus may damage the solution.

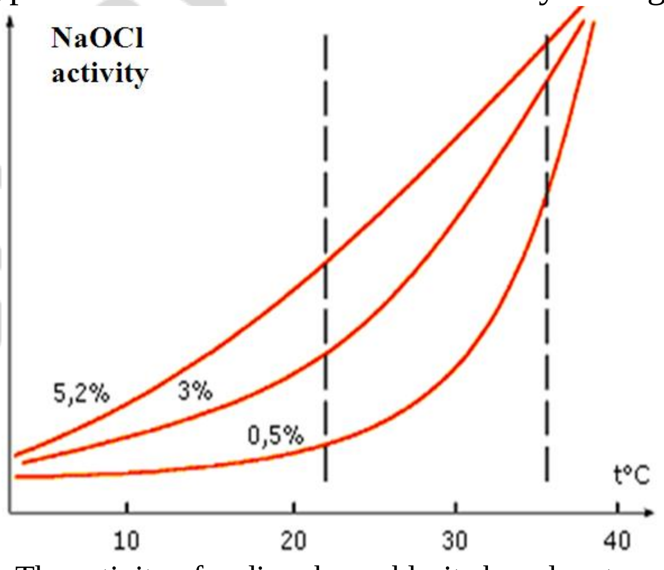


Fig. 4. The activity of sodium hypochlorite based on temperature

Fig. 5. To warm NaOCl, syringes filled with NaOCl are placed in 40–50 °C water bath

Specialized irrigating syringes and needles. Most studies have shown that unaided irrigation requires at least a size #25 apex for it to reach more apical portions of the canals. Newer specialized side venting endodontic syringes with a narrower diameter (32 gauge) are available which aid in getting irrigant closer to the apex and help the irrigant to move sideways (fig. 6).

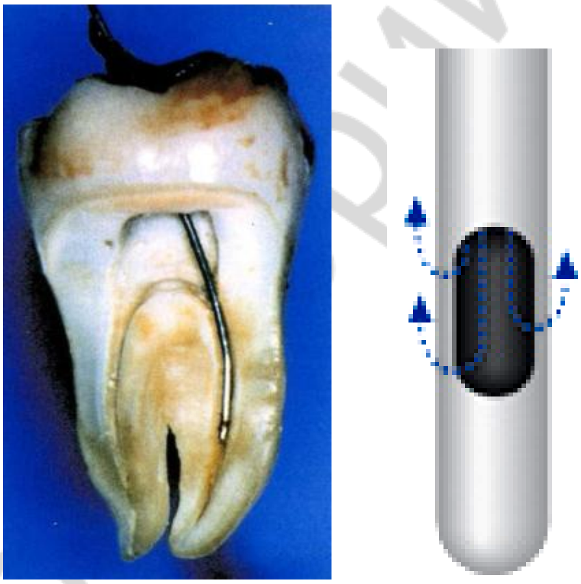


Fig. 6. Specialized irrigating syringes and needles

Ultrasonics significantly improves the efficacy of NaOCl irrigation. When a small file (mostly a #15) is held free in an enlarged canal filled with NaOCL and is ultrasonically activated, the ultrasonic energy warms the solution in the canal and the resonant vibrations make aqueous NaOCL move into the ramifications in the canal difficult to reach, an effect called "acoustic streaming". It should be noted that for acoustic streaming to be effective, the ultrasonically activated file should be free in the canal and not bind to the canal walls. Therefore, to use a #15 file in an ultrasonic handpiece 1mm short of the working length, the canal should be enlarged apically at least.

Sodium hypochlorite products commonly used in dentistry (fig. 7).
Chlorox 3–5 % (USA)
Parkan 3 % (France)
Belodez 3–5,2 % (Russia)

Fig. 7. Sodium hypochlorite products in dentistry

Complications of accidental spillage of sodium hypoclorite solution.

1. Damage to clothing.

Accidental spillage of sodium hypochlorite is probably the most common accident to occur during root canal irrigation. Even spillage of minute quantities of this agent on clothing will lead to rapid, irreparable bleaching. The patient should wear a protective plastic bib, and the practitioner should exercise care when transferring syringes filled with hypochlorite to the oral cavity

2. Eye damage.

Seemingly mild burns with an alkali such as sodium hypochlorite can result in a significant injury as the alkali reacts with the lipid in the corneal epithelial cells, forming a soap bubble that may cause blurring of vision and patchy colouration of the cornea. Immediate ocular irrigation with a large amount of water or sterile saline is required, which is followed by an urgent referral to an ophthalmologist. The referral to the nearest eye department should ideally be made immediately by telephone. The use of adequate eye protection during endodontic treatment should eliminate the risk of occurrence of this accident, but sterile saline should always be available to irrigate eyes injured with hypochlorite. It has been advised that eyes exposed to undiluted bleach should be irrigated for 15 minutes with a liter of normal saline.

3. Damage to skin.

Skin injury with an alkaline substance requires immediate irrigation with water as alkalis combine with proteins or fats in tissue to form soluble protein complexes or soaps. These complexes permit the passage of hydroxyl ions deep into the tissue, thereby limiting their contact with the water dilutant on the skin surface.

Water is the agent of choice for irrigating skin and it should be delivered at low pressure as high pressure may spread hypochlorite into the patient's or rescuer's eyes.

4. Damage to oral mucosa.

Surface injury is caused by the reaction of alkali with protein and fats as in the case of eye injuries described above. Swallowing of sodium hypochlorite requires the patient to be monitored following immediate treatment. It is worth noting that skin damage can result from secondary contamination.

Complications arising from hypochlorite extrusion beyond the root apex.

1. Chemical burns and tissue necrosis.

When sodium hypochlorite is extruded beyond the root canal into the periradicular tissues (fig. 8), the effect is one of a chemical burn leading to a localised or extensive tissue necrosis. Given the widespread use of hypochlorite, this complication is fortunately very rare indeed. A severe acute inflammatory reaction of the tissues develops. This leads to rapid tissue swelling both intraorally within the surrounding mucosa and extraorally within the skin and subcutaneous tissues.

Fig. 8. NaOCl extrusion in periapical tissue

The swelling may be oedematous, haemorrhagic or both, and may extend beyond the region that might be expected with an acute infection of the affected tooth (fig. 9, 10). Sudden onset of pain is a hallmark of tissue damage, and may occur immediately or be delayed for several minutes or hours. Involvement of the maxillary sinus will lead to acute sinusitis. Associated bleeding into the interstitial tissues results in bruising and ecchymosis of the surrounding mucosa and possibly the facial skin, and may include the formation of a haematoma. A necrotic ulceration of the mucosa adjacent to the tooth may occur as a direct result of the chemical burn. This reaction of the tissues may occur within minutes or may be delayed and appear some hours or days later. If these symptoms develop, urgent telephone referral should be made to the nearest maxillofacial unit. Patients will be assessed by the on-call maxillofacial team. Treatment is determined by the extent and rapidity of the soft tissue swelling but may necessitate urgent hospitalisation and administration of intravenous steroids and antibiotics.

Fig. 9. Bruising and oedema of the patient who presented with NaOCl extrusion into the soft tissues

Fig. 10. Swelling and extraoral ecchymosis following inadvertent extrusion of sodium hypochlorite (3 %) through the apical foramen of the maxillary left cuspid

Although the evidence for the use of antibiotics in these patients is not necessary, secondary bacterial infection is a distinct possibility in areas of necrotic tissue and, therefore, they are often prescribed as part of the overall patient management. Surgical drainage or debridement may also be required depending on the extent and character of the tissue swelling and necrosis.

2. Neurological complications.

There have been described paraesthesia and anaesthesia affecting the mental, inferior alveolar and infraorbital branches of the trigeminal nerve following inadvertent extrusion of sodium hypochlorite beyond the root canals. Normal sensation may take many months to completely resolve. Facial nerve damage was first described in 2005 (Witton et al.). The buccal branch of the facial nerve was affected. Patients exhibited loss of the naso-labial groove and a down turning of the angle of the mouth. Their motor function was regained in several months.

Preventive measures that should be taken to minimise potential complications with sodium hypochlorite:

– Plastic bib to protect the patient's clothing.
– Provision of protective eye-wear for both patient and operator.
– The use of a sealed rubber dam for isolation of the tooth under treatment.
– The use of side exit needles for root canal irrigation (fig. 11).
– Irrigation needle a minimum of 3 mm short of the working length (fig. 12, 13).
– Avoidance of wedging the needle into the root canal.
– Avoidance of excessive pressure during irrigation.

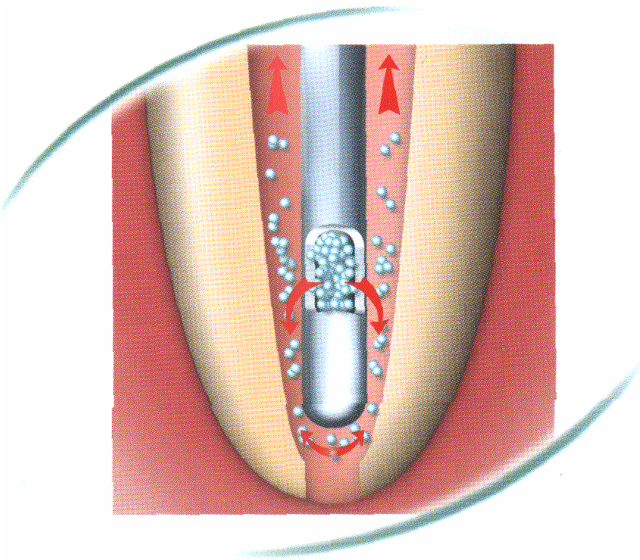


Fig. 11. Special endodontic needle using

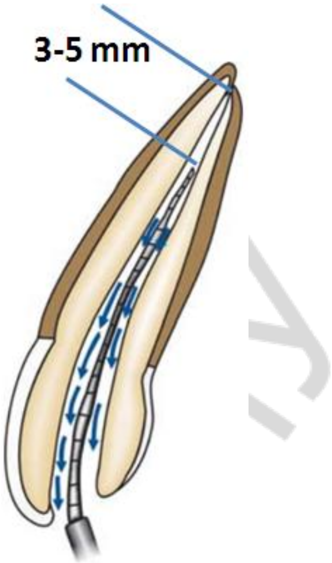


Fig. 12. Correct position of the endodontic needle in the root canal

Fig. 13. Placement of rubber stop on the irrigation needle

Emergency management of accidental hypochlorite damage. Eye injuries:

1. Irrigate gently with normal saline. If normal saline is insufficient or unavailable, tap water should be used.
2. Refer for an ophthalmologist's opinion.

Skin injuries:

1. Wash thoroughly and gently with normal saline or tap water.

Oral mucosa injuries:

1. Copious rinsing with water.
2. Analgesia if required.
3. If visible tissue damage, antibiotics are administered to reduce risk of secondary infection.
4. If any possibility of ingestion or inhalation, refer to emergency department.

Treatment strategy in case of a NaOCl incident

1. The patient informed on the cause and severity of complication.
2. Pain control: local anaesthesia, analgesics.
3. In severe cases: referral to hospital.
4. Extraoral cold compresses for reducing swelling.
5. *In a day:* warm compresses and frequent warm mouth rinses for stimulating local systemic circulation.
6. Daily recall for control of recovery.
7. Antibiotics: not obligatory. Only in cases of high risk or evidence of secondary infection.
8. Antihistamine: not obligatory.
9. Corticosteroids: controversial.
10. Further endodontic therapy with sterile saline or chlorhexidine as root canal irrigants.

The main advantages and disadvantages of using sodium hypochlorite in dental practice are described in table 1.

Table 1

Sodium hypochlorite resume

Advantages	Disadvantages
It causes tissue dissolution. It has antibacterial and bleaching action. It causes lubrication of canals. Economical. Easily available	Because of high surface tension, its ability to wet dentin is reduced. Irritant to tissues, if extruded periapically, it can result in severe cellular damage. If comes in contact, it causes inflammation of gingiva because of its caustic nature. It can bleach the clothes if spilt. It has bad odour and taste. Vapours of sodium hypochlorite can irritate the eyes. It can be corrosive to the instruments

ETHYLENE DIAMINE TETRA ACETIC ACID (EDTA), CITRIC ACID

Although sodium hypochlorite appears to be the most desirable single endodontic irrigant, it cannot dissolve inorganic dentin particles and thus cannot prevent the formation of a smear layer during instrumentation. In addition, calcifications hindering mechanical preparation are frequently encountered in the canal system. Demineralising (chelating) agents such as ethylenediaminetetraacetic acid (EDTA) and citric acid have therefore been recommended as adjuvants in root canal therapy. Chelating agent is defined as a chemical which combineswith a metal to form chelate (fig. 14). Although citric acid appears to be slightly more potent at similar concentration than EDTA, both agents show high efficiency in removing the smear layer.

Functions of EDTA:

1) lubrication;
2) emulsification;
3) holding debris in suspension;
4) smear layer removal (fig. 15).

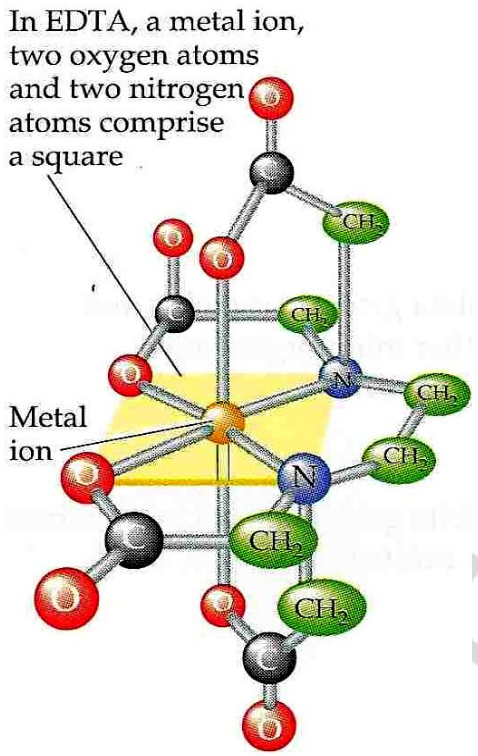


Fig. 14. Chelate forming

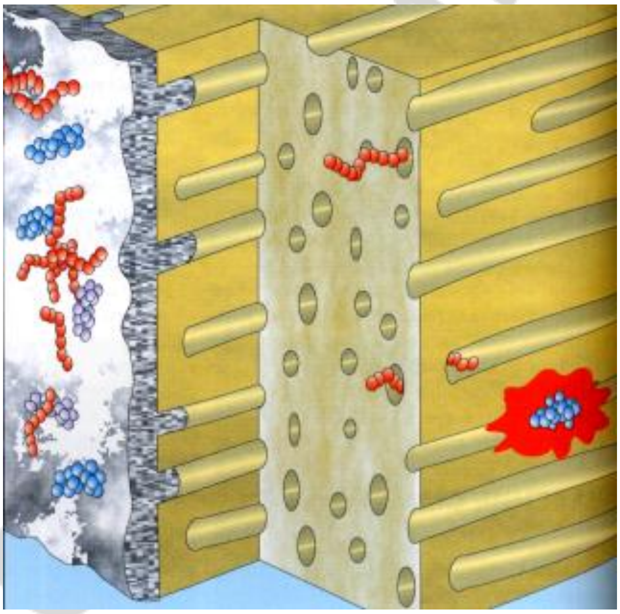


Fig. 15. The internal surface of the root canal with a smear layer and without it

Mechanism of EDTA action:

1. It inhibits growth of bacteria and ultimately destroys them by starvation because EDTA chelates with the metallic ions in medium which are necessary for growth of microorganisms.

2. EDTA has a self limiting action. It forms a stable bond with calcium and dissolves dentin, but when all chelating ions have reacted, an equilibrium is reached, which prevents further dissolution.

Use of EDTA:
1) it has dentin dissolving properties;
2) it helps to enlarge narrow canals;
3) makes manipulation of instruments easier;
4) reduces time needed for debridement.

Chelating agents can be applied in liquid or paste-type 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(Unident). 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.

The others commonly used EDTA products in dentistry (fig. 16):

Pastes: Canal + (Septodont, France);
Dilaton-gel (Systema, Russia);
Endogel № 1 (VladMiVa, Russia)

Liquid: Largal Ultra (Septodont, France).

Fig. 16. EDTA products in dentistry

Citric acid. Another commonly used chelating agent for removing the smear layer as irrigating solution is citric acid. It can be used alone or in combination with other irrigants but EDTA or citric acid should never be mixed with sodium hypochlorite because EDTA and citric acid strongly interact with sodium hypochlorite. This immediately reduces the available chlorine in the solution, thus making it ineffective against bacteria.

CHLORHEXIDINE

Chlorhexidine is a potent antiseptic which is widely used for chemical plaque control in the oral cavity. Aqueous solutions of 0.1 to 0.2 % are recommended for that purpose, while 2 % is the concentration of root canal irrigating solutions usually found in endodontic literature. As with sodium hypochlorite, heating chlorhexidine irrigant of a lower concentration could increase its local efficacy in the root canal system while keeping the systemic toxicity low. Chlorhexidine does not have any tissue dissolution properties and, therefore, cannot be used as a primary irrigant in endodontics. It is, however, used as an adjuvant to NaOCL.

Chlorhexidine is more effective against gram-positive bacteria than gram-negative bacteria. However, in primary endodontic infections, which are usually poly-microbial, gram-negative anaerobes predominate. Chlorhexidine is particularly effective against E. Faecalis, a bacterium commonly found in failed root canals. Therefore, the use of chlorhexidine as an adjuvant is suggested especially in nonvital and retreatment cases. Chlorhexidine has an affinity to dental hard tissues, and once bound to the surface, has a prolonged antimicrobial activity, a phenomenon called "substantivity". Therefore, it is often used as the final irrigant.

Despite its usefulness as the final irrigant, chlorhexidine cannot be advocated as the main irrigant in standard endodontic cases, because: a) chlorhexidine is unable to dissolve necrotic tissue remnants, b) chlorhexidine is less effective on gram-negative than on gram-positive bacteria.

Mechanisms of action. Chlorhexidine is a broad spectrum antimicrobial agent. The antibacterial mechanism of chlorhexidine is related to its cation icbisbiguanide molecular structure. The cationic molecule is absorbed to the negatively charged inner cell membrane, thus causing leakage of intracellular components. At low concentration, it acts as a bacteriostatic, whereas at higher concentrations it causes coagulation and precipitation of cytoplasm and, therefore, acts as a bactericidal agent. It shows optimal antimicrobial action between pH 5.5–7.0.

Chlorhexidine 2 % products in dentistry: Belsol № 2 (VladMiVa, Russia) (fig. 17).

Fig. 17. Chlorhexidine 2 % product in dentistry

Chlorhexidine is a very reactive compound and forms precipitates with both EDTA and NaOCl (fig. 18). Thus the root canal should be rinsed with distilled water before another irrigant solution is used to avoid chemical reaction.

Fig. 18. Demonstration of precipitates formed with 2 % chlorhexidine

HYDROGEN PEROXIDE

It is a clear, odourless liquid. It is mainly a 3 % solution which is used as an irrigating agent (fig. 19).

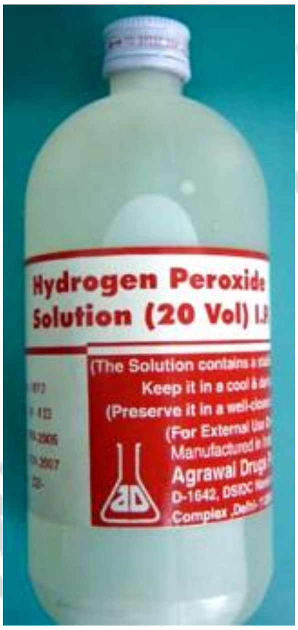


Fig. 19. Hydrogen peroxide 3 % product in dentistry

Mechanism of action:

1. It is highly unstable and easily decomposed by heat and light. It rapidly dissociates into H_2O + [O] (water and nascent oxygen). On coming in contact with tissue enzymes, catalase and peroxidase, atomic [O] produces bactericidal effect but this effect is transient and diminishes in presence of organic debris.

2. It causes oxidation of bacterial sulfhydryl group of enzymes and thus interferes with bacterial metabolism.

3. A rapid release of [O] nascent oxygen in case of contact with organic tissue results in effervescence 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.

Hydrogen peroxide use. It is used as an irrigating solution either alone or alternatively with sodium hypochlorite. The advantages of using alternating solutions of 3 % H_2O_2 and 3 % NaOCl are:

1. Effervescent reaction by hydrogen peroxide bubbles pushes debris mechanically out of the root canal.
2. Solvent action of sodium hypochlorite on organic debris.
3. Disinfecting and bleaching action by both solutions.

While using in combination with sodium hypochlorite, always use sodium hypochlorite in the end because hydrogenperoxide can react with pulp debris and blood to produce gas (nascent oxygen) which builds up pressure on closing the tooth, which can result in severe pain.

Table 2

Overview on the features of aqueous irrigants frequently recommended for endodontic use

Compound (recommended concentration)	Type	Action on endodontic Taxa-Biofilm	Tissue dissolution capacity	Endotoxin inactivation	Action on smear layer	Caustic potential	Allergic potential
Hydrogen peroxide, 3 %	Peroxygen	+	–	–	–	D. o. c.	–
Sodium hypochlorite, 1–5.25 %	Halogen-releasing agent	++	+++	+	++ on organic compounds	D. o. c.	+
Chlorhexidine, 2 %	Bisguanide	++	–	+	–	D. o. c.	+
EDTA, 15–17 %	Polyprotic acid	+	–	–	++ on inorg. compounds	–	–
Citric acid (10–50 %)	Organic acid	–	–	–	+++ on inorg. compounds	–	–
– absent or minor, + reported, ++ definitely present, +++ strong. D. o. c.: depending on concentration							

Modified from Matthias Zehnder, Dr. med. dent., PhD
Root Canal Irrigants JOE — Vol. 32, N 5, May 2006.

IRRIGATION TECHNIQUE AND PROTOCOL

Irrigation methods (Van der Sluis, 2007):

– Manual (conventional);
– Ultrasonic;
– Sound (EndoActivator);
– Laser;
– Hydrodynamic (RinsEndo, EndoVac).

Although the technique of irrigation is simple and easy, still care should be taken while irrigating with different syringes or system. The following points should be in mind while irrigating the canal:

1. The solution must be introduced slowly and passively into the canal.

2. The needle should never be wedged into the canal and should allow an adequate back-flow.

3. Blunted needles of 25 gauge or 27 gauge are preferred.

4. In case of small canals, deposit the solution in the pulp chamber. Then the file will carry the solution into the canal. Capillary action of a narrow canal will stain the solution. To remove the excess fluid, either an aspirating syringe or 2 × 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 the apical area, the canals must be enlarged to size 30 and to a larger size.

6. Regardless of the delivery system, irrigants must never be forcibly inserted into the apical tissue but gently placed into the canal.

7. For effective cleaning, the needle delivering the solution should be in close proximity to the material to be removed.

8. In case of large canals, the tip of the needle should be introduced until resistance is felt, then withdraw the needle 2–3 mm away from that point and irrigate the canal passively. For removing the solution, sterile gauge pack or paper points should be used.

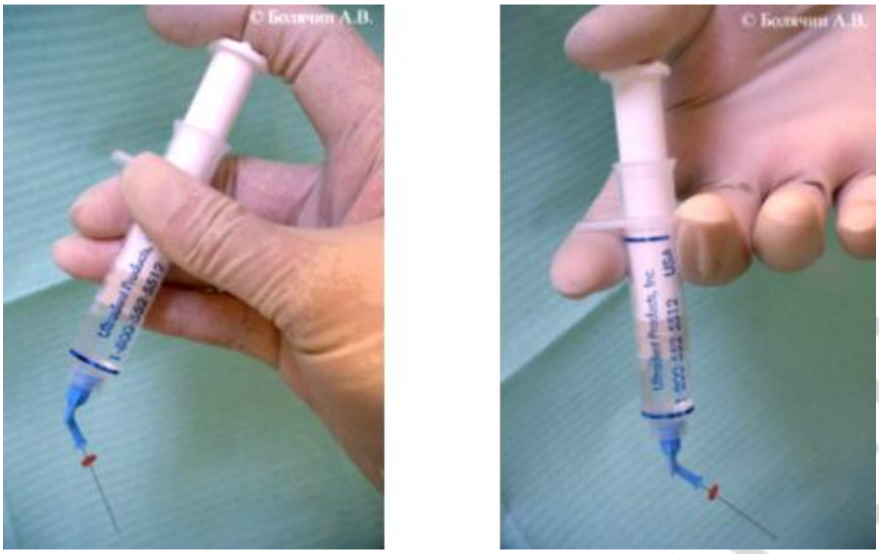
9. In order to clean effectively in both anterior and posterior teeth canals, a blunt bend of 30° in the centre of the needle can be given to reach the optimum length to the canal.

10. Volume of irrigation solution is more important than concentration or type of the irrigant.

Manual (conventional) irrigation. It is important to use a needle that is thin enough to reach the apical part of the root canal. The solution is normally not injected more than one mm of the needle penetration depth. The needle should be free and not bind in the canal. If back-pressure (resistance to injection) is felt, then the needle should be withdrawn and injection attempted again. Notched needle tips prevent forceful injection of solution apically. Side venting needles also prevent apical extrusion of the irrigant. Slow introduction of the irrigant in combination with constant back-and-forth motions of the needle will minimize inadvertent removal of sodium hypochlorite to the periapical tissues. It is better to put the pressure on the plunger of the syringe with the forefinger (not thumb) for better tactile control (fig. 20).

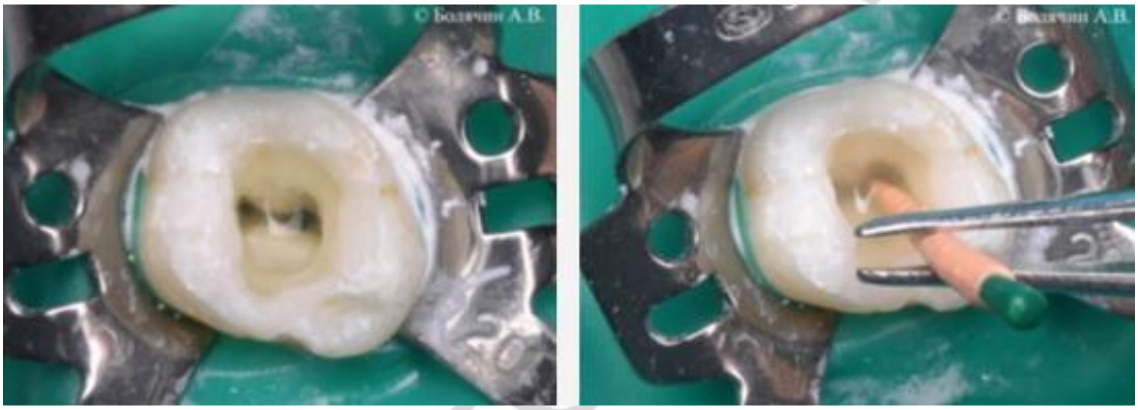
Traditional (manual) methods of irrigation using a syringe and endodontic needle provide satisfactory disinfection in the middle coronal third of the root canal, but are not sufficiently effective from the view point of cleaning its walls at the apex (O'Connel, 2000). Machtou (1980) proposed a method for the activation of irrigant in the root canal using gutta percha point (fig. 21).

Endodontic tip *NaviTip FX (Ultradent)* is an irrigation needle and brush for mechanical activation of irrigants that are used at the same time (fig. 22).



a ***b***

Fig. 20. The position of the fingers on the plunger irrigation syringe (*a*) correct and (*b*) incorrect (A. V. Bolyachin, T. S. Belyaeva)



a ***b***

Fig. 21. Activation of irrigant in the root canal using gutta percha point:
a — a clear irrigant solution fills the root canals and pulp chamber; *b* — turbidity of the solution shows its activity

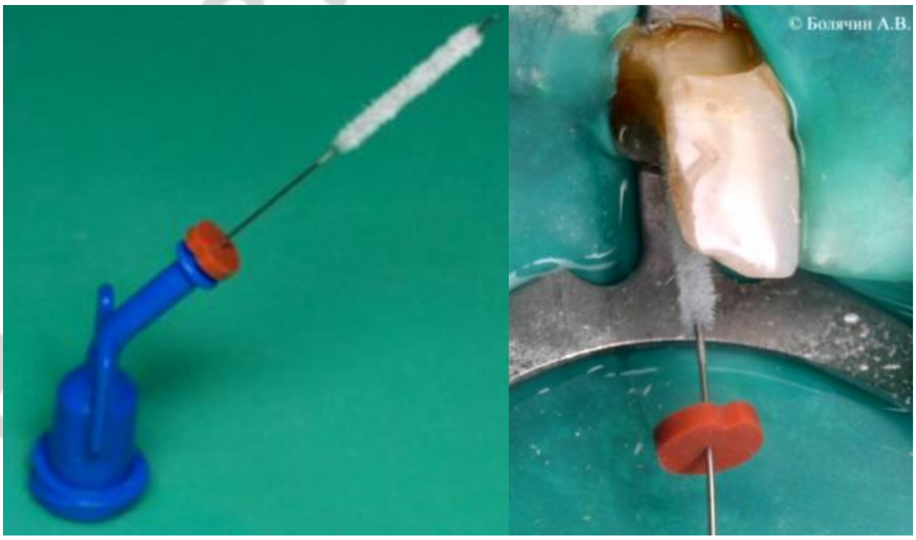


Fig. 22. NaviTip FX (Ultradent)

Ultrasonic irrigation. For successful irrigation, it is necessary to deliver the disinfectant solution to the entire working length of the root canal. With classical endodontic syringes and needles it is not always possible to achieve; in the narrow canals of the root the irrigant solution does not reach the apex due to surface tension, leaving a so-called “air bubble”. As a result, the apical portion of the root canal remains inadequately treated.

Ultrasonic irrigation has shown to clean the root canals or eliminate bacteria from the walls better than conventional methods (hand instrumentation alone). Use of ultrasonics causes continuous flow of an irrigant in the canal, thus preventing accumulation of debris in the canal (fig. 23, 24).

Fig. 23. Ultrasonic activation of irrigating solution

Fig. 24. Ultrasonic tip

Mechanism of action. When a small file is placed in the canal, ultrasonic activation is given. The ultrasonic energy passes through irrigating solution and exerts its “acoustic streaming or scrubbing” effect on the canal wall (fig. 25). This mechanical energy warms the irrigant solution and dislodges debris from the canal.

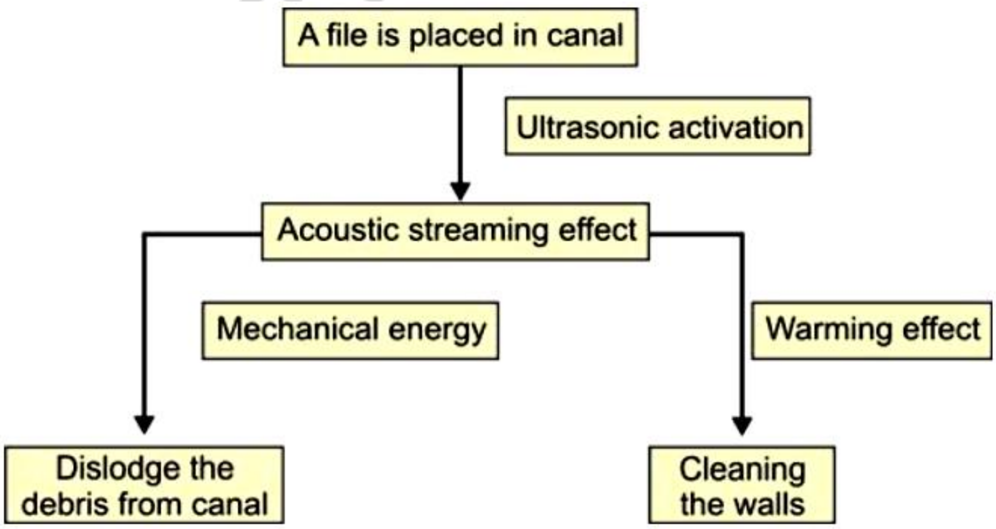


Fig. 25. Ultrasonic irrigation mechanism

The combination of activating and heating the irrigating solution is adjunct in cleaning the root canal.

Advantages:

1. It cleans the root canal walls better than conventional ones.
2. It removes the smear layer efficiently.
3. It dislodges the debris from the canal better due to acoustic effect.

Disadvantages:

1. Ultrasonic preparation of the canal is found to be unpredictable.
2. It can lead to excessive cutting of the canal walls and may damage the finished preparation.

Sound and hydrodynamic irrigation techniques (EndoActivator, RinsEndo). EndoActivator system (Dentsply) consists of the handpiece and different sizes of replaceable tips polymer (fig. 26). This sound system is designed for safe-channel activation of various kinds of reagents for the hydrodynamic effect. It is very important that sound irrigation technique highly improves disinfection of the root canal system (Walmsley. Lumley and Laird, 1989; Pitt, 2005; Jensen et al., 1999).

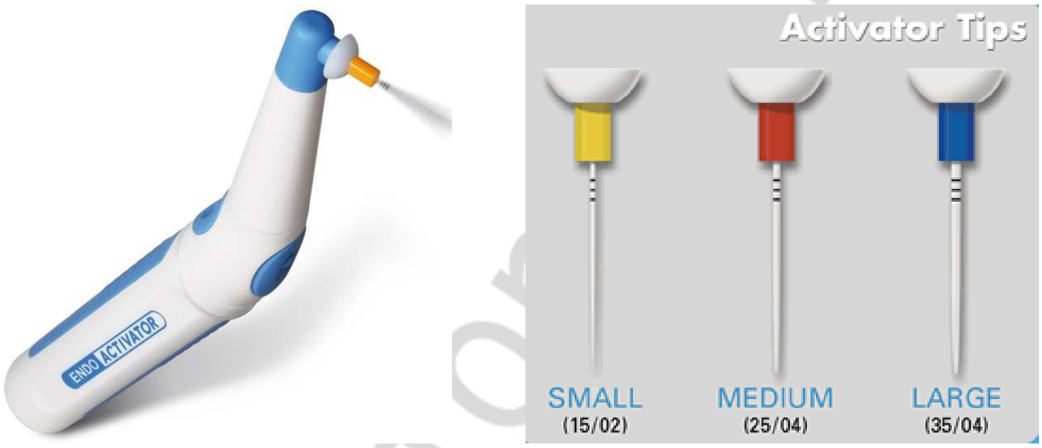


Fig. 26. EndoActivator System (Dentsply)

Studies show the EndoActivator system is able to clean the lateral branches of the canal, remove smear layer and biofilm in curved molar canals (Caron, 2007; Gulabivala, 2006). In the well-formed canals, EndoActivator efficiency increases. The main function of the EndoActivator device is to produce strong intracanal shaking fluid flow and acoustic cavitation. Such hydrodynamic activation promotes penetration, distribution and movement of irrigants into the most inaccessible places of the root canal system (Guerisolo et al., 2002).

RinsEndo is a highly effective and time efficient method of irrigating pre-pared root canals. The RinsEndo handpiece fully irrigates right to the apex. Germs and debris are effectively removed even under complicated anatomical conditions such as strong curvature and small diameters. RinsEndo replaces time consuming manual syringe irrigation. The ergonomic titanium handpiece accepts a specially designed single-use cannula with a 7 mm long aperture. The long aperture eliminates blockage enabling the irrigation solution to reach and disinfect all portions of the canal. A protective stopper guards against splatter and serves as a positioning device for the saliva ejector. During operation, RinsEndo employs exclusive, patented pressure suction technology to thoroughly flush the canal. In the pressure phase, 65 microliters of solution are automatically drawn from the attached syringe and aspirated into the canal. In the suction phase, the solution used and air are aspirated back. The pressure created by RinsEndo irrigation is lower than the pressure created by a syringe during manual irrigation.

Fig. 27. RinsEndo system

The following irrigation protocol is suggested:

1. The primary irrigant should be sodium hypochlorite. Hypochlorite should be used copiously after each instrument to flush out debris. This also ensures fresh irrigant in the canal every time to enhance the antimicrobial action. Once the shaping procedure is complete and the canal is enlarged to a sufficient size, fill the canal with hypochlorite. Insert a #15 ultrasonic file that is loose in the canal and activate ultrasonically for 30 seconds. Irrigate again with NaOCl and repeat the procedure for 5 minutes.

2. Next, irrigate copiously with aqueous EDTA or citric acid for about 1 minute to remove the smear layer. About 5 to 10 ml of solution should be used.

3. The final irrigation should be with chlorhexidine. As traces of EDTA or citric acid can weaken root dentin, copious amount of chlorhexidine should be used to wash out the demineralizing solution. Chlorhexidine is a good final irrigant because it exhibits substantivity.

INTRACANAL MEDICATIONS

Microorganisms have been well known to play a role in pulpal and periapical diseases. The bacteria associated with primary endodontic infections are mixed, but are predominantly gram-negative anaerobic rods, whereas the bacteria associated with secondary infection comprise only one or a few bacterial species — the most important of which is *Enterococcus facecalis*. Eradication of causative microorganisms during root canal treatment procedures helps attain successful results.

Because of the complex nature of the root canal system and the presence of many inaccessible areas, a combination of mechanical instrumentation and irrigation is necessary to decrease the amount of bacteria/microorganisms in the root canal system. However, chemomechanical preparation is often not sufficient, and many bacteria may remain in the root canal system.

Intracanal medicaments in endodontics have been used for a number of reasons including the elimination or reduction of microorganisms, rendering canal contents inert, prevention of post-treatment pain, and to enhance anaesthesia. Inter-appointment intracanal medication has been unequivocally shown to contribute to favourable outcomes when treating endodontic infections. The need for intracanal medication is greater in those cases where bacteria are resistant to routine treatment, and where the therapy cannot be successfully completed due to the presence of pain or continuing exudate. Some endodontic conditions are ideally treated in several appointments which may be extended over a long period of time. This allows various medicaments to be used depending on the status of the pulp, periapical tissues, hard dental tissues (such as cementum) and the condition of the apical foramen (i. e., "open", or fully developed and unaffected by resorption). The minimum interappointment time interval should be not less than 14 days, since inflammation takes at least 10–14 days to subside or heal, but longer periods are generally more desirable as most medicaments take 3–4 weeks to reach their maximum concentration within the peripheral dentine. In addition, if signs or symptoms are not subsiding, then a longer period of medication time or an alternative medicament may be necessary. Many hand and rotary instrumentation techniques tend to produce round preparations (especially in oval canals) leaving some areas uninstrumented and hence possibly containing infected debris. It has been estimated that as much as 50 % of the canal wall may remain uninstrumented during preparation. The remaining necrotic tissue remnants may provide a source of nutrition for any surviving bacteria.

In addition, bacteria are likely to remain in dentinal tubules after instrumentation. If this occurs, calcium hydroxide and other disinfectants that require direct physical contact with pathogens may be ineffective. The presence of microorganisms inside a root canal may not necessarily lead to the failure of treatment, but their absence will certainly lead to healing.

Medicaments are used as an aid to improve the predictability and prognosis of endodontic treatment. They are used in endodontic therapy in order to:

– eliminate or destroy any remaining viable bacteria in the root canal system that have not been destroyed by chemomechanical preparation processes (i. e., instrumentation and irrigation);

– reduce periradicular inflammation and hence reduce pain;

– help eliminate apical exudate if it is present;

– prevent or arrest inflammatory root resorption if it is present;

– prevent reinfection of the root canal system by acting as both a chemical and a physical barrier if temporary or interim restoration breaks down.

A root canal medicament (disinfectant) should have following properties:

1. It should be effective germicide and fungicide.
2. It should be non-irritating to pulpal tissue.
3. It should remain stable in the solution.
4. It should have prolonged antimicrobial action.
5. It should remain active in the presence of blood and pus, etc.
6. It should have low surface tension.
7. It should not interfere with repair of periapical tissue.
8. It should not stain the tooth.
9. It should be capable of inactivation in the culture media.
10. It should not induce immune response.

The main *indications for the root canal temporary obturation*:

1. Intracanal medicament.
2. Apexification.
3. Exudation control.
4. Periapical lesions.
5. Root resorption.
6. Temporary root filling.
7. Perforations.
8. Underdeveloped pulpless teeth.

There are many different intracanal medicaments used in dentistry (fig. 28). But the material of choice is c*alcium hydroxide.* The use of calcium hydroxide in endodontics was introduced by Hermann in 1920. It has taken up a unique position in endodontics. After its successful clinical applications for a variety of indications, multiple biological functions have been attributed to calcium hydroxide.

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 killing bacteria which may cause infection.

Calcium hydroxide is available in:

a) paste form: single paste *(Metapaste, BIOMED Co., LTD. (South Korea),)* or in combination with iodoform *(Metapex, BIOMED Co., LTD. (South Korea))* (fig. 28);

b) powder form: powder form is mixed with saline and anaesthetic solution (fig. 29). For placement in root canals it is coated with the help of paper points, spreaders or lentulo spirals.

Fig. 28. $Ca(OH)_2$ product in dentistry (paste form)

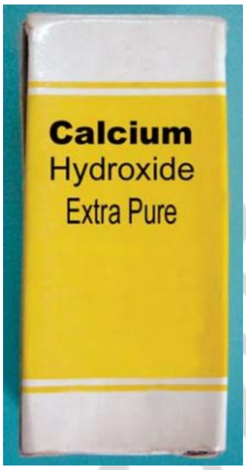


Fig. 29. $Ca(OH)_2$ product in dentistry (powder form)

Indications of calcium hydroxide use:

- in weeping canals;
- in treatment of phoenix abscess;
- in resorption cases;
- for apexification;
- during pulpotomy;
- for non-surgical treatment of periapical lesion;
- in cases of direct and indirect pulp capping;
- as sealer for obturation.

Disadvantages of calcium hydroxide as intracanal medicament:

1. Difficult to remove from the canals.
2. Decreases setting time of zinc oxide eugenol-based cements.

Use of calcium hydroxide in weeping canal cases (fig. 30). Sometimes a tooth undergoing root canal treatment shows constant clear or reddish exudation associated with periapical radiolucency. The tooth can be asymptomatic or tender on percussion. When opened during the next appointment, exudates stops but it again reappears during the following appointment. This is known as “a weeping canal”. In these cases, the tooth with exudates is not ready for filling, since culture reports normally show negative bacterial growth; antibiotics are of no help in such cases. For such teeth, dry the canals with sterile absorbent paper points and place calcium hydroxide into the canal (fig. 31). To exclude bacterial contamination of the root canal system, adequate temporary seals between appointments are required (for example, glass ionomer cement). By the next appointment, one finds a dry canal, ready for obturation. It happens because pH of periapical tissues is acidic in the weeping stage which gets converted into basic pH by calcium hydroxide. $Ca(OH)_2$ also builds up the bone in the lesion due to its calcifying action.

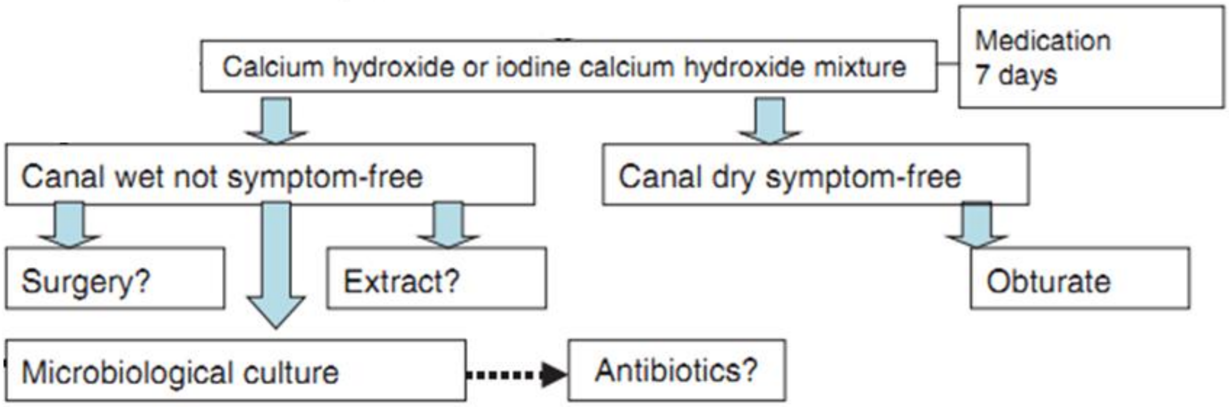


Fig. 30. Weeping canal cases treatment algorithm

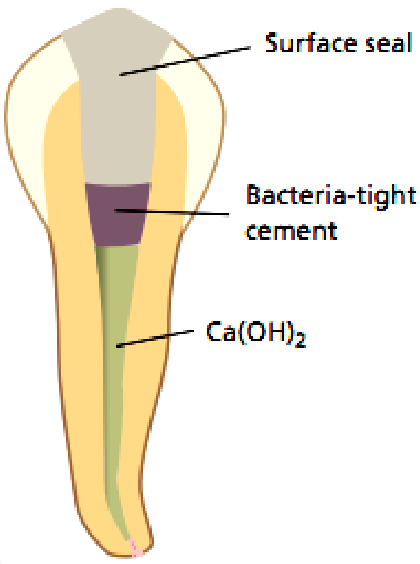


Fig. 31. Closing the root canal system between appointments

CHARACTERISTICS OF SOME OTHER INTRACANAL MEDICAMENTS

Essential oils, eugenol. It has been used in endodontics for many years. It is 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 eugenol. These are divided into low dose (beneficial effects) and high dose (toxic effects). Low doses show anti-inflammatory activity while high doses exert cytotoxic effects.

Use of eugenol:

1. Used as an intracanal medicament.
2. Used as a root canal sealer.
3. Part of temporary sealing agents.

Aldehydes. Formaldehyde, paraformaldehyde and glutaraldehyde are intracanal medicaments commonly used in root canal therapy. These are water soluble protein denaturing agents and are considered among the most potent disinfectants. They are mainly applied as disinfectants for surfaces and medical equipment which cannot be sterilized, but they are quite toxic and allergic, and some may even be carcinogenic.

Formocresol. Formocresol contains formaldehyde as its main ingredient, and is still a widely used medicament for pulpotomy procedures in primary teeth but its toxic and mutagenic properties are of concern.

Composition of formocresol. Formaldehyde — 19 percent. Cresol — 35 percent. Water and glycerine — 46 percent. Formocresol is used as dressing for pulpotomy to fix the retained pulpal tissue.

Paraformaldehyde. It is a polymeric form of formaldehyde, and is commonly found as a component of some root canal obturating materials like endomethasone. It slowly decomposes to give out formocresol, its monomer. Its properties are similar to formaldehyde that is toxic, allergenic and genotoxic in nature. All phenolic and similar compounds are highly volatile with low surface tension. Therefore, if they are placed on a cotton pellet in the chamber of a tooth during treatment, the vapours will permeate the entire canal preparation, so placement on a paper point is unnecessary. Only a tiny quantity of medication is needed for effectiveness, otherwise, chances of periapical irritation are increased.

Corticosteroid-antibiotic combinations. Medications that combine antibiotic and corticosteroid elements are highly effective in the treatment of overinstrumentation; they must be placed into the inflamed periapical tissue by a paper point or reamer to be effective. Tetra-Cortril, Corti-sporin, Mycolog, and other combinations are available for their use in endodontics. *Ledermix* is one of the best known corticosteroid-antibiotic combination (fig. 32).

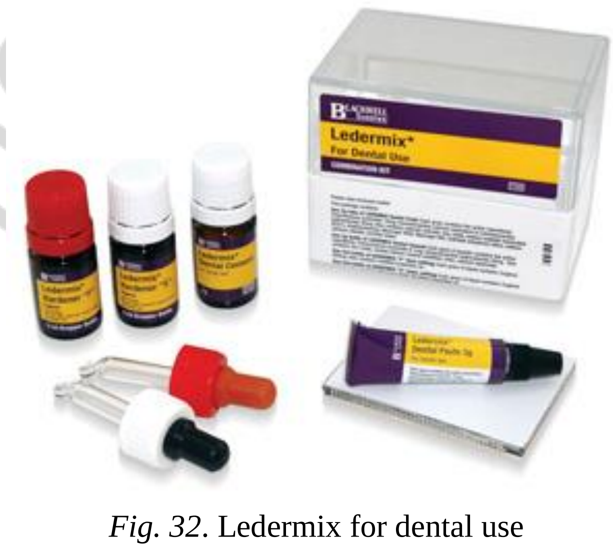


Fig. 32. Ledermix for dental use

The corticosteroid constituent reduces periapical inflammation and gives almost an instant relief of pain to the patient who complains of extreme tenderness to percussion after canal instrumentation. While the antibiotic constituents present in the corticosteroid antibiotic combination prevent the overgrowth of microorganisms when the inflammation subsides.

Elimination of microbial contamination from the root canal system is a prerequisite to the successful outcome of root canal treatment. The evidence shows that mechanical instrumentation, irrigation, and use of intraappointment medication are all important in this regard. However, all of the currently available antimicrobial materials for root canal irrigation and medication have limitations, and the search for an ideal irrigant and intraappointment medicament continues.

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Учебно-методическое пособие

На английском языке

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