Root Canal Irrigation

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Irrigation is probably the most underrated procedure in Endodontic therapy. While most articles or presentations spend a great deal of time on shaping procedures, not much emphasis is given for irrigation. This has led to a great deal of confusion on the type of irrigant, the protocol and the method of use. The purpose of this article is to discuss root canal irrigants, irrigation techniques and irrigation protocol.

The need for irrigation

It is a well-documented fact that microorganisms either remaining in the root canal space after endodontic therapy or re-colonizing the filled root canal system are the main cause of Endodontic failure. It is also well known that root canals are most often, not straight cones from orifice to apex but can consist of ribbons, fins, lateral canals and multiple ramifications (Fig.1).

Fig. 1: Root canals are not always coned or cylindrical but consist of ribbons, fins, lateral branches and numerous ramifications. It is thorough irrigation we rely on to clean these ramifications

No instrument we know can actually reach these numerous ramifications. It has been shown that 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. Needless to say, the choice of irrigants, their protocol and method of use can greatly influence the outcome of endodontic therapy.

Endodontic microbiology

Primary root canal infections are polymicrobial, typically dominated by obligate anaerobic bacteria. The most frequently isolated microorganisms before root canal treatment include Gram-positive anaerobic cocci, Gram-negative anaerobic rods, Gram-positive anaerobic and facultative rods, Gram-positive facultative Streptococcus species and Lactobacillus species. The obligate anaerobes are rather easily eradicated during root canal treatment. On the other hand, facultative bacteria such as nonmutans Streptococci, Enterococci, and Lactobacilli, once established, are more likely to survive chemo-mechanical instrumentation and root canal medication. Enterococcus faecalis Can be frequently isolated from failed root canals. Bacteria can combine together and form Biofilms, which are colonies within an extracellular polysaccharide matrix. It has been shown that bacteria within biofilms are much more resisitant to the chemical effects of irrigants than bacteria which are isolated. Therefore invitro studies that focus on the effects of chemicals on individual bacteria may not actually replicate what happens within the confines of the root canal. An irrigation protocol should be aimed at removing these Biofilms.

Functions of an irrigant

An irrigant is expected to perform the following functions:

- Have a broad antimicrobial spectrum and high efficacy against anaerobic and facultative microorganisms organized in biofilms
- Dissolve pulp tissue and organic debris
- Inactivate endotoxin
- Be a good lubricant
- Remove smear layer
- Be systemically nontoxic, non-caustic to periodontal tissues and have little potential to cause an anaphylactic reaction

A single irrigant may not be enough to satisfy all the above requirements. Ideal Irrigation is therefore a combination of multiple irrigants.

Types of irrigation solutions

Countless solutions have been used for irrigation. These include inert solutions like Isotonic saline to highly caustic solutions like formaldehyde. This article will only discuss currently used irrigants. The most common irrigants used today are:

1. Sodium hypochlorite
2. Chlorhexidine
3. Chelating agents (EDTA, Citric acid)

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 currently used substances, Sodium hypochlorite is the most ideal, as it covers more of the requirements for endodontic irrigant than any other known compound. NaOCL has the unique capacity to dissolve organic tissue. It dissolves pulp, necrotic material and the 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 the doctor should wear protective glasses. Rubber dam should be used to prevent the leaching into patient's oral tissues. Forceful extrusion of NaOCL into the periapical region can cause a severe inflammatory reaction.

Concentration of NaOCL

Determinig the right concentration of NaOCL for endodontic usage has been a controversial subject for many years. Various concentrations from 0.5% to 5.25% have been tried out. It has been suggested that higher the concentration, the better the antibacterial and tissue dissolution properties. It is also true that the higher the concentration the more the chances of tissue reaction. 5.25% Hypochlorite has an unpleasant odour and this odour decreases as the concentration decreases. The difference in odour is evident when a 5.25% NaOCL solution is compared to a 3% solution. It has been shown that a 1% solution of NaOCL is enough to dissolve pulp tissue during the course of an endodontic therapy. Most studies show no difference in the reduction of microbial flora when 5.25% NaOCL was compared to 1% NaOCL. Therefore based on current research, there does not seem to be any rationale for using NaOCL at concentrations higher than 1%.

Methods to improve the efficacy of NaOCl

Currently there are two methods by which the efficacy of NaOCl solutions can be improved:

Heating: Increasing the temperature of hypochlorite solutions improves both tissue dissolution and anti microbial properties of NaOCL. The capacity of a 1% NaOCl at 45°C to dissolve human dental pulps was found to be equal to that of a 5.25% solution at 20°C. Coffee cup warmers can be used in the clinic to keep NaOCl warm.

Ultrasonics: 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 ultrasonically activated, the ultrasonic energy warms the solution in the canal and the resonant vibrations cause movement of aqueous NaOCL into the difficult to reach ramifications in the canal, 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 to a size 25.

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 atleast 40 minutes to completely dissolve pulp tissue. 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. In simple cases like the one shown in Fig. 2, even if the shaping is complete within 5 minutes, one has to spend another 30 minutes activating NAOCL in the canal to ensure thorough cleaning.

Fig 2 A: Persistent pain in a tooth after root canal treatment has been done. Root canal obturation appears satisfactory.

Fig 2B:Post Re-treatment radiograph shows filled lateral canal missed during previous treatment. Earlier treatment failed probably because NaOCL was not placed in the canal for sufficient duration to clean the lateral canal

Chlorhexidine: Chlorhexidine is a potent antiseptic, which is widely used for chemical plaque control in the oral cavity. Solutions of 0.1 to 0.2% are normally used for periodontal therapy, while 2% is the concentration of root canal irrigating solutions usually found in the endodontic literature. As with sodium hypochlorite, heating a Chlorhexidine irrigant of lesser 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 non vital and retreatment cases. Chlorhexidine has an affinity to dental hard tissues, and once bound to a surface, has prolonged antimicrobial activity, a phenomenon called "Substantivity". Therefore it is often used as the final irrigant.

Chelating agents (EDTA, Citric acid)

Mechanical instrumentation produces a smear layer that adheres on the walls of the root canal. This smear layer is composed of both organic and inorganic particles. This deposit can be penetrated by bacteria and may offer protection to biofilms adhering to root canal walls. Furthermore, the smear layer interferes with a tight adaptation of currently used root canal sealers to dentin walls and may therefore promote micro leakage. It is therefore important to remove the smear layer before obturation.

Although NaOCl is the preferred irrigant in Endodontic therapy, it cannot remove inorganic components and therefore cannot prevent the formation of a smear layer. One has to rely on demineralizing agents like EDTA and citric acid to remove the smear layer.

In addition, Demineralizing agents soften dentin and makes shaping procedures easier. It has also been suggested that de-mineralizing agents may help in detaching biofilms.

Formulations and their usage

Chelating agents are available in both liquid and paste forms. Both citric acid and EDTA are highly biocompatible and safe to use. The liquid form is the preferred method of use. EDTA is commercially available as a 17% solution. Citric acid is used in concentrations of 10 to 20%. The paste forms **(RC prep, Glyde etc.)** are essentially EDTA combined with urea peroxide in a water-soluble carbowax (polyethylene glycol) vehicle. The pastes are not capable of removing the smear layer and should be only used as lubricants during shaping procedures.

It is important to remember that both EDTA and citric acid react strongly with sodim hypochlorite. Earlier this reaction was considered beneficial. However, current research shows this reaction decreases the effect of sodium hypochlorite. Both EDTA and citric acid immediately reduce the available chlorine in solution, rendering the sodium hypochlorite irrigant ineffective on bacteria and necrotic tissue. Hence, it has been suggested that citric acid or EDTA should never be mixed with sodium hypochlorite. Once irrigation has been completed with NaOCL, the remaining NAOCL should be removed and only then should the irrigation with EDTA begin.

EDTA and citric acid modifications

EDTA has been modified earlier by adding Centrimide, a quartenary ammonium compound to reduce surface tension and increase penetration. This product was called EDTAC.

Recently, citric acid has been combined with Doxycycline and a detergent (tween 80) to form a final irrigant called MTAD. Although manufacturers claim superiority of these solutions, the current available literature is devoid of long term clinical follow-ups that support their superiority over plain EDTA or citric acid.

Irrigation technique and protocol

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. Therefore bulky needles prevent the irrigant from effectively debriding the deeper ramifications. A 27 or 30 gauge needle should be used. 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 (Fig. 3) prevent forceful injection of solution apically. Side venting needles (Fig.4) also prevent apical extrusion of irrigant.

Fig 3: Notched needle tips

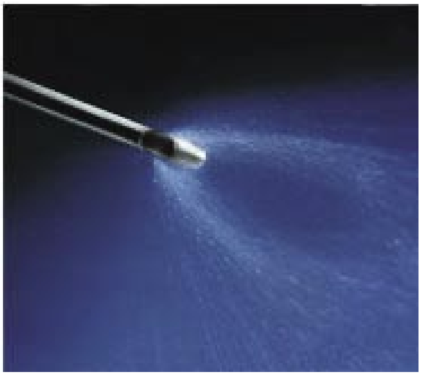

Fig 4: Side venting irrigation needles prevent apical extrusion of irrigants.

The following irrigation protocol is suggested

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 everytime 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.

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.

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.

Newer irrigation devices

Photo activated disinfection (PAD): The PAD device (Fig. 5) is a new device that uses a photoactivated solution for bacterial destruction.

The PAD device has two compnents

Fig. 5A: The PAD device.

PAD solution

A dilute solution containing pharmaceutical grade tolonium chloride.

SaveDent laser

A low power 635 nm laser light source which optimally activates the solution through a disposable handpiece.

The procedure is relatively simple. After application of the PAD solution into the canals and a brief interval to allow penetration and attachment to bacteria, laser light delivered using the special handpiece tip activates the disinfection process, and the bacteria are destroyed. PAD solution is activated by 635nm light and acts as a photosensitiser, releasing reactive oxygen species that disrupt the membrane of the microorganism. Independently, the laser and solution have no effect, but in combination produce a powerful anti-bacterial action. This device is however expensive.

Sterilox

Sterilox is a device that attempts to use Electrochemical activation (ECA) as a tool for irrigation. The ECA technology represents a new scientific paradigm developed by Russian scientists at the All-Russian Institute for Medical Engineering (Moscow, Russia, CIS). The ECA technology is based on the process of transferring liquids into a metastable state via an electrochemical unipolar (anode or cathode) action through the use of an element/ reactor ('Flow-through Electrolytic Module' or FEM). The FEM consists of an anode, a solid titanium cylinder with a special coating that fits coaxially inside the cathode, a hollow cylinder also made from titanium with another special coating. A ceramic membrane separates the electrodes. Electrochemical treatment in the anode and cathode chambers of the diaphragm electrolyzer (for unipolar electrochemical treatment) transforms water and low mineral solutions into a metastable state that is characterized by modified values of physical-chemical parameters, particularly, the pH and oxidation-reduction potential .The FEM is capable of producing types of solutions that have bactericidal and sporicidal activity, yet are odourless, safe to human tissue and essentially noncorrosive for most metal. FEMs have been incorporated into a variety of delivery systems (devices) for creating electrochemically activated solutions. The ECA devices have been in widespread commercial use in Russia and the Commonwealth of Independent States for a number of years, mainly in the areas of hospital disinfection, sterilization, and in agricultural and industrial processes. Sterilox is an attempt to bring the same technology into Endodontic irrigation.

EndoActivator

The EndoActivator is a soon to be released device designed by Cliff Ruddle. This consists of a small battery operated cordless handpiece which delivers sonic energy onto nylon tips which can be attached to the handpiece. The advantage of attaching Nylon tips would make the device more flexible and less prone for breakage when compared to ultrasonic files. This device promises to produce even more acoustic streaming than conventional ultrasonic devices.

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