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Review Article

EFFECTIVE ROOT CANAL IRRIGATION - A KEY FACTOR OF ENDODONTIC TREATMENT - REVIEW OF THE LITERATURE

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ABSTRACT

The smear layer is created by an instrument touching the canal walls and is composed of organic and inorganic components. Sodium hypochlorite (NaOCl) is the most commonly used antibacterial irrigant, which is able to dissolve necrotic and vital pulp tissue, the organic components of dentin as well as biofilm. Any type of agitation (using temperature or ultrasound) of the NaOCl is a good way to increase the effectivness of this irrigating solution. Ethylenediaminetetraacetic acid (ethylenediaminetetraacetate or EDTA) was the first chelator used in dentistry as an agent capable of chemically softening the root canal dentin, dissolving the smear layer and decreasing dentin permeability. The citric acid demineralizes and softens dentin tissue and removes the smear layer on the radicular walls. Residual citric acid must be thoroughly flushed out to prevent continuing demineralization along the length of the tubules. Chlorhexidine digluconate has a broad spectrum of antibacterial action, sustained action and low toxicity. However, unlike NaOCl, it cannot dissolve organic substances and necrotic tissues present in the root canal system. Hydrogen peroxide (H_2O_2) is a clear, colorless, odorless liquid, which is active against viruses, bacteria, and yeasts. Although H_2O_2 has long been used in disinfection and canal irrigation in endodontics, the available literature does not support its use over that of other irrigating solutions. None of the presently available endodontic irrigants satisfy the requirements of ideal root canal irrigant. Newer root canal irrigants and techniques are studied for potential replacement of standard used.

The purpose of this article is to present an overview on classical irrigating solutions in endodontics and some new concepts to improve the delivery of solution to the apical portion of the root canal system and the quality of removal of the smear layer.

INTRODUCTION

The goal of irrigation in root canal treatment is to improve the cleaning and disinfection process within the root canal system. Irrigation serves as a physical flush to remove debris as well as an antimicrobial agent, tissue solvent and lubricant. Root canal irrigation plays a key role in the success of endodontic treatment, because it helps in the progressive removal of the smear layer and neutralizes the root canal microbial flora.

The main goal of instrumentation and cleaning is to facilitate effective irrigation, disinfection and filling. A lot of studies using advanced techniques demonstrated that proportionally large areas of the main root-canal wall remain untouched by the instruments, emphasizing the importance of chemical means of cleaning and disinfecting all areas of the root canal (Fig. 1a,1b). The smear layer is a combination of organic and inorganic debris that is present on the root canal walls following instrumentation. It's composed of dentinal shavings, tissue debris, odontoblastic processes and microbial elements [Violichand Chandler, 2010].

Factors affecting the irrigation are concentration and volume of the irrigation solution, anatomy and diameter of the canal, the method of delivering the irrigation solution, temperature of the irrigant and contact time with tissue. The effect of combining different types of irrigation solutions and use of ultrasonic activation affects the result of irrigation too.

Desired functions of irrigating solutions are washing action, lubricating the canal walls, dissolution of organic and inorganic tissue, eradication of bacteria and yeasts (also in biofilm). Simultaneously the irrigant should not irritate or damage vital periapical tissue and not weaken the tooth structure.

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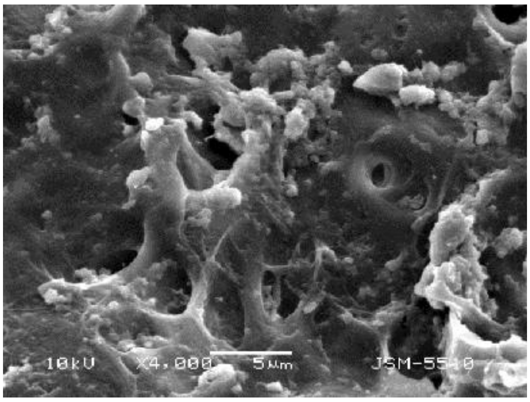

Figure 1a Area of uninstrumented root canal wall

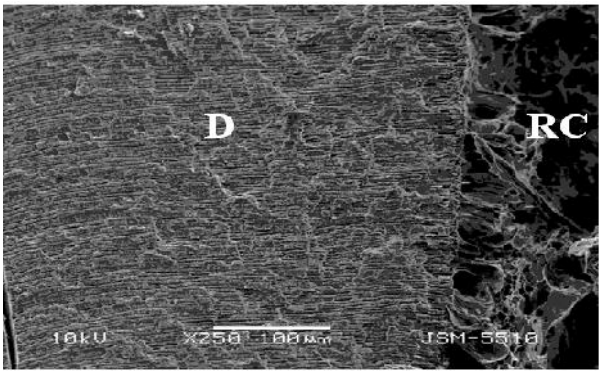

Figure 1b Area of the root canal with pulp residues (**D**=dentin; **RC**=root canal).

The biomechanical cleaning and shaping of the root canal greatly reduces the number of bacteria [Byström and Sundqvist, 1981]. Nevertheless, studies have shown that bacteria often persist [Peters, 2004]. The biological function of the irrigants is related to their antimicrobial effect [Meztger, 2010]. Irrigants have traditionally been delivered into the root-canal space using syringes and metal needles of different size and tip design. Clinical experience and research have shown, however, that this classic approach typically results in uneffective irrigation. There is no single irrigating solution that sufficiently covers all of the functions required from an irrigant alone. The optimal irrigation is based on the combined use of two or several irrigating solutions, in a specific sequence, to predictably obtain the goals of safe and effective irrigation. Irrigants have traditionally been delivered into the root canal space using syringes and metal needles of different size and tip design.

The irrigation has a central role in the endodontic treatment. During and after instrumentation, the irrigants facilitate removal of microorganisms, tissue remnants and dentin chips from the root canal through a flushing mechanism. Irrigants can also help to prevent packing of the hard and soft tissue in the apical root canal and extrusion of infected material into the periapical area. Some irrigating solutions dissolve either organic or inorganic tissue in the root canal.

The Smear Layer

The smear layer is madeof an amorphous layer of microcrystalline debris. It is created by an instrument touching the canal walls (Fig.2 a/,b/). It is composed of organic and inorganic components. Mader *et al*. described in an SEM study two confluent layers [Mader *et al*., 1984]:

1st - a superficial layer of 1-2 µm along the canal walls, and
2nd -a layer packed within the tubules to a depth of as much as 40 µm.

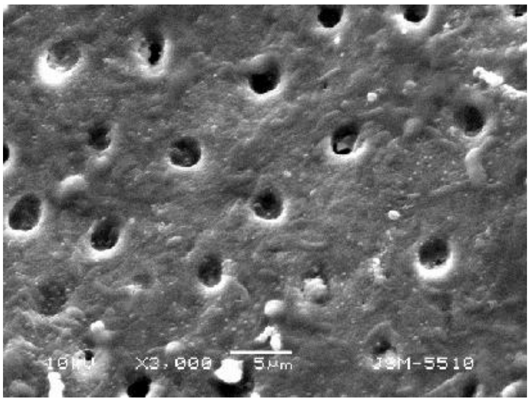

Figure 2a Smear layer on radicular dentin

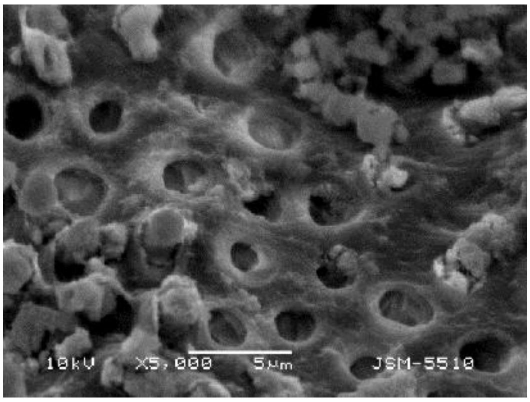

Figure 2b Dentin tubules plugs (magnification x 5 000). (magnification x 3 000).

The use of a small file in the ultrasonic unit after completion of cleansing and shaping aids help in the removal of the smear layer - research pending publication shows that sonic units achieve the same results. The use of 5.25% NaOCl to remove the organic portion of the smear layer, after the use of EDTA to remove the inorganic portion of the smear layer is effective (Fig. 3 a/,b/). Most endodontists use 5% to 6 % NaOCl. To date, the reported incidence rate of hypochlorite accidents is very low. Hypochlorite accidents occur when a sufficient volume of NaOCl escapes to the periapical area and causes wide tissue destruction, as well as dramatic pain, which may last for several hours. Some patients will end up having large, dark blue areas on their facial skin but, nevertheless correct irrigation techniques will minimize the possibility of accident.

The smear layer is made of particles ranging in size from less than 0.5–15 µm. The presence of the smear layer has been postulated to be an avenue for leakage and source of substrate for bacterial growth and ingress [Baumgartner & Mader, 1987; Goldman, 1982; Pashley, 1984; Pitt Ford and Roberts, 1990]. Studies have shown that smear layer on the dentinal walls of biomechanically instrumented root canals occluded the dentinal tubules [White *et al*., 1984].

Technically, the smear layer may interfere with the penetration of gutta-percha into the tubules and the adhesion and penetration of root canal sealers into the dentinal tubules [Gettlemen *et al*., 1991; Oksan *et al*., 1993; White *et al*., 1984; White *et al*., 1987]. But sodium hypochlorite by itself is not sufficient for total cleaning of the endodontic system [Ayhan, 1999]. It has no effect on the smear layer and its high surface tension does not allow for its cleaning and disinfection of the root canal system's totality. For this reason, and according to the different clinical situations, we will have to use other irrigants in combination with sodium hypochlorite [Byström *et al*., 1985].

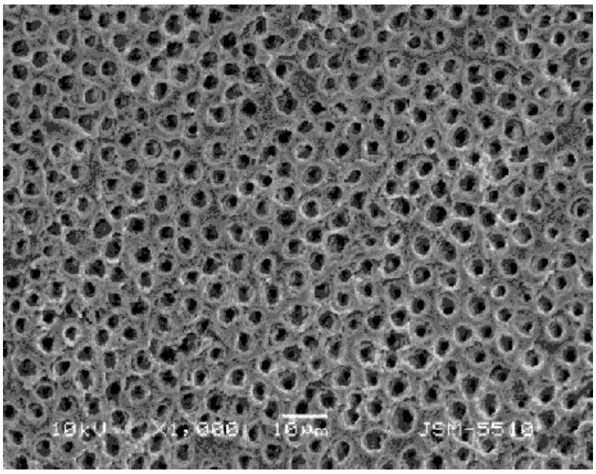

Figure 3a Radicular dentin without smear layer

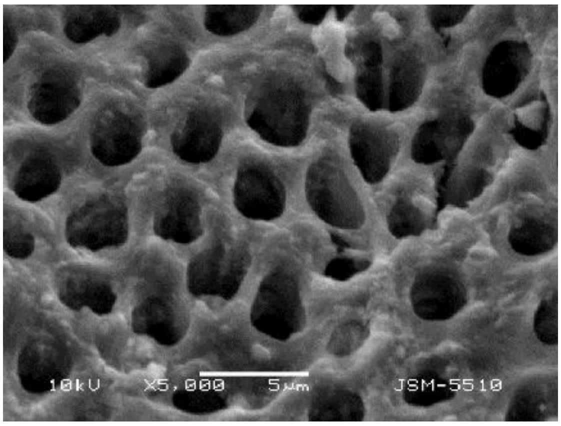

Figure 3b Open dentin tubules (magnification x 5 000). (magnification x 1 000).

The irrigation act is often dismissed during endodontic treatment and must not be overlooked. It is one of the major keys of success for endodontic treatment. The irrigation usually reduced to a needle on the tray has to be systematically evaluated in order to become an endodontic entity having a precise chronology and codification [Sleiman and Khaled, 2005].

Irrigants

Sodium Hypochlorite (NaOCl)

Sodium hypochlorite (NaOCl) is the most commonly used irrigating solution. It is an antibacterial agent, able to dissolve necrotic and vital pulp tissue, the organic components of dentin as well as biofilm [Senia, 1971]. There has been much controversy over the concentration of hypochlorite solutions to be used in endodontics. The antibacterial effectiveness and tissue dissolution capacity of aqueous hypochlorite is a function of its concentration, and so is its toxicity [Zehnder, 2006]. Hypochlorite has a bactericidal, sporicidal and virucidal effect and show far greater tissue dissolving effect on necrotic than on vital tissues. These features prompted the use of aqueous sodium hypochlorite in endodontics as the main irrigant from 1920. Chlorine is one of the most widely distributed elements on earth. It is not found in a free state in nature, but it exists in combination with sodium, potassium, calcium and magnesium. In the human body, chlorine compounds are part of the nonspecific immune defense. They are generated by neutrophils via the myeloperoxidase-mediated chlorination of a nitrogenous compound or set of compounds [Zehnder, 2006]. HOCl exerts its effects by oxidizing sulfhydryl groups within bacterial enzyme systems, thereby disrupting the metabolism of the microorganism, resulting in the killing of the bacterial cells.

One of the methods to improve the efficacy of sodium hypochlorite was to use heated solution. This improves their immediate tissue-dissolution capacity. Furthermore, heated hypochlorite solutions remove organic debris from dentin shavings more efficiently than unheated counterparts [El Karim, 2007]. Ultrasonic activation of sodium hypochlorite has also been advocated, as this would be accelerate chemical reactions, create cavitation effects, and achieve a superior cleansing action and deeper penetration of irrigants [Berutti *et al*., 1997; Buck *et al*., 1999; Zehnder, 2006].

NaOCl ionizes in water into Na^+ and the hypochlorite ion, OCl^-, establishing equilibrium with hypochlorous acid (HOCl). At acidic and neutral pH, chlorine exists predominantly as HOCl, whereas at high pH of 9 and above, OCl^- predominates. Hypochloric acid is responsible for the antibacterial activity. The OCl^- ion is less effective than the undissolved HOCl. Hypochloric acid disrupts several vital functions of the microbial cell, resulting in cell death. Interpreting these chemical reactions, sodium hypochlorite acts as a solvent for organic and fat degrading fatty acids, transforming them into fatty acid salt (soap) and glycerol (alcohol) that reduces the surface tension of the remaining solution [Estrela *et al*., 2002; Grossman and Meiman, 1941]. NaOCl is commonly used in concentrations between 0.5% and 6%. It is a potential microbial agent, killing most bacteria instantly on direct contact. It also effectively dissolves pulpal remnants and collagen, the main organic components of dentin. Hypochlorite is the only root canal irrigant of those in general use that dissolves necrotic and vital organic tissue.

Increasing the temperature of hypochlorite irrigant to 60°C, its antimicrobial and tissue-dissolving effects are significantly increased. After complete instrumentation the canal should be agitate with an ultrasonic tip for approximately one minute. The literature currently does not point to any one form of agitation as being superior to any other. However, any type of agitation (increasing the temperature or ultrasound) of the NaOCl is far better than none.

This protocol will eradicate most of the bacteria located in the canals. However, it may not always kill *E. faecalis* [Perez *et al*., 1996]. These bacteria can often be found in biofilm in the canal and in the tubules (Fig.4). They are persistent and often resistant to calcium hydroxide as well as NaOCl. *E. faecalis* seems to be especially prominent in endodontic cases that have had root canal treatment and are failing [Stuart *et al*., 2006].

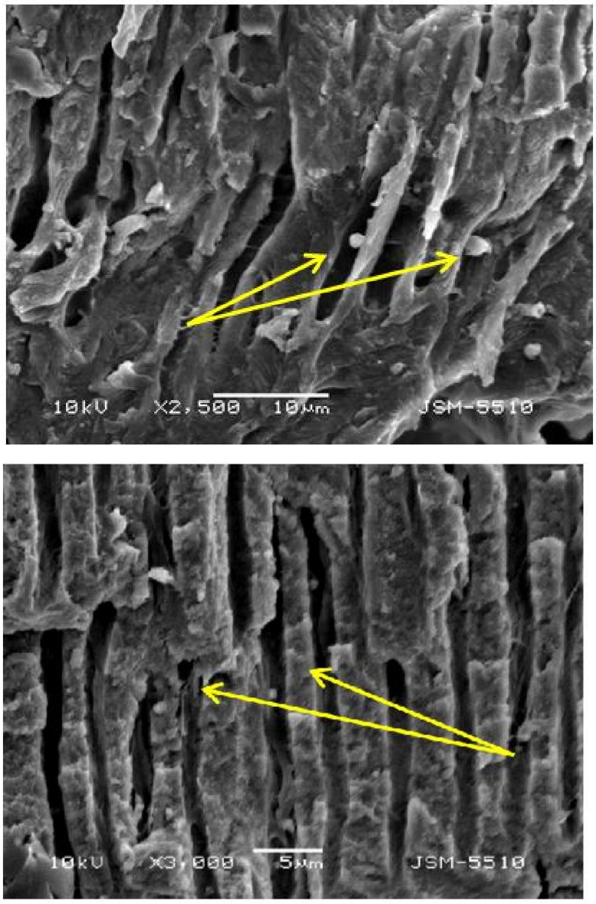

Figure 4. a,b. *E. faecalis* into the dentin tubules(*yellow arrows*).

EDTA

The demineralizing effect of chelators acts indistinguishably on the smear layer and the root dentin, with consequent exposure of collagen and decrease of dentin microhardness [De-Deus *et al*., 2008;Hülsmann *et al*., 2003]. Chelating agents were introduced to endodontics by Nygaard-Østby in 1957 as a medicament in preparation of narrow and calcified root canals. A liquid solution of ethylenediaminetetraacetic acid (ethylenediaminetetraacetate or EDTA) was the first chelator used in dentistry as an agent capable of chemically softening the root canal dentin, dissolving the smear layer and decreasing dentin permeability. It is interesting to mention that when the root canal is irrigated with NaOCl followed by EDTA, the collagen degradation with a consequent decrease of flexural strength is caused by a hypochlorite action and has no association with the demineralization promoted by the final rinse with EDTA [Zhan *et al*, 2010]. Chelators such as EDTA form a stable complex with the calcium ions in dentin. In this moment, carboxyl groups of the EDTA molecule are ionized, releasing hydrogen atoms that complete with the calcium ions [Hottel *et al*., 1999; Hülsmann *et al*.,2003; Yoshida and Shinohara, 1995]. The findings of the different studies showed that 15% EDTA and 10% citric acid are effective in reducing the microhardness of the most superficial dentin layer of the root canal lumen, which facilitates the biomechanical preparation considerably under clinical conditions [Cruz-Filbo *et al*., 2011; Hülsmann *et al*., 2007].

Citric Acid

The citric acid irrigant is a low-viscosity 40% solution of citric acid in purified water. Citric acid is a mild, slightly antibacterial, biocompatible chelating agent that forms a relatively stable chelate complex with the calcium ions in the dentine. This demineralizes and softens hard dental substance and removes the smear layer on the canal wall, thus opening the dentine tubules and even widening them. Residual citric acid must be thoroughly flushed out to prevent continuing demineralization along the length of the tubules. Opening up the dentine tubules facilitates adaptation of the root canal sealer, generally improving the sealing ability. This effect is further enhanced by activating the solution with ultrasound. Contraindication of citric acid is allergic reactions [Basrani *et al*., 2007].

Citric acid solution must be dosed under appropriately hygienic conditions. In cases of root canal orifices that are hard to locate, 40% citric acid solution can be dripped into the endodontic access. The root canal orifices become visible after a few minutes. The solution is injected into the root canal for preparation and dilatation using an endo-capillary tips or suitable rinsing cannula. This should be repeated throughout the entire root canal preparation procedure. Alternate rinsing with sodium hypochlorite to remove necrotic tissue, dentine residues and the smear layer, rinsing with water between applications. Following root canal preparation, the removal of the 40% citric acid solution should be done by rinsing with sodium hypochlorite and saline solution. This is followed by drying of the root canal with sterile paper point.

Chlorhexidine

Chlorhexidine gluconate has been used for the past 50 years for caries prevention, for periodontal therapy and as an oral antiseptic mouthwash. It has a broad spectrum of antibacterial action, sustained action and low toxicity [Johnson and Noblett, 2009; Shabahang *et al*., 2008]. Because of these properties, it has also been recommended as a potential root canal irrigant [Johnson and Noblett, 2009; Lee *et al*., 1990]. The major advantages of chlorhexidine over NaOCl are its lower cytotoxicity and lack of foul smell and bad taste. However, unlike NaOCl, it cannot dissolve organic substances and necrotic tissues present in the root canal system. In addition, like NaOCl, it is unable to kill all bacteria and cannot remove the smear layer [Estrela *et al*., 2008; Shabahang *et al*., 2008].

Hydrogen Peroxide (H_2o_2)

It is a clear, colorless, odorless liquid. H_2O_2 is active against viruses, bacteria, and yeasts. In endodontics, H_2O_2 has long been used because of its antimicrobial and cleansing properties. It produces hydroxyl free radicals, which attack several cell components such as proteins and DNA. It has been particularly popular in cleaning the pulp chamber from blood and tissue remnants, but it has also been used in canal irrigation. Although H_2O_2 has long been used in disinfection and canal irrigation in endodontics, the available literature does not support its use over that of other irrigating solutions.

Hydrogen peroxide is highly unstable and easily decomposed by heat and light. It rapidly dissociates into H_2O+O (water + nascent oxygen). The liberated oxygen has bactericidal effect but this effect is transient and diminishes in presence of organic debris. The rapid release of nascent oxygen on contact with organic tissue results in effervesce (bubbling) action which aids in mechanical debridement by dislodging dentin debris and necrotic tissue particles and floating them to the surface.

Advantages of using alternating 3% H_2O_2 with NaOCl solution are effervescent reaction (bubbles pushes debris mechanically out of the root canal), solvent action of sodium hypochlorite on organic debris and disinfection and bleaching effect by both solutions. H_2O_2 is unable to remove smear layer alone [Shiozawa, 2000]. Always use NaOCl last because hydrogen peroxide release of nascent oxygen on contact with organic tissue which may build up pressure and cause pain. Soft tissue emphysema may occur when hydrogen peroxide irrigant enforced beyond the apical foramen.

Mtad

MTAD is an aqueous solution of 3 % doxycycline (a broad-spectrum antibiotic), 4.25 % citric acid (a demineralizing agent) and 0.5 % polysorbate 80 detergent (Tween 80). It was introduced as an alternative irrigant of EDTA to remove the smear layer by Torabinejad *et al*. [Torabinejad *et al*., 2003]. It has a combined chelating and antibacterial properties [Williamson *et al*., 2009]. It is mixed as a liquid and powder prior to use. MTAD has been recommended in clinical practice as a final rinse after completion of conventional chemomechanical preparation because it has no the ability to dissolve organic tissue. The effectiveness of MTAD to completely remove the smear layer is enhanced when a low concentration of NaOCl (1.3 %) is used as an intracanal irrigant before placing 1 ml of MTAD in a canal for 5 min and rinsing it with an additional 4 ml of MTAD as the final rinse [Basrani, 2015].

Qmix

QMix is an irrigation solution used as a final rinse. Recent scientific reports indicates that QMix, an experimental irrigant containing a mixture of a bisbiguanide antimicrobial agent, a polyaminocarboxylic acid calcium-chelating agent, saline, and a surfactant, might be as effective as EDTA and MTAD at removing smear layer and opening dentine tubules when used after an initial rinse with NaOCl [Dai *et al*., 2011]. It is in the market for very short time, so, there is no research available yet.

Interactions between Irrigating Solutions

NaOCl and EDTA are the two most commonly used irrigating solutions. As they have different characteristics and tasks, it has been tempting to use them as a mixture. However, EDTA and CA instantly reduce the amount of chlorine when mixed with sodium hypochlorite, resulting in the loss of NaOCl activity. Thus, these solutions should not be mixed [Zehnder, 2006]. CHX has no tissue-dissolving activity and there have been efforts to combine CHX with hypochlorite for added benefits from the two solutions. However, CHX and NaOCl are not soluble in each other and a brownish-orange precipitate (parachloroaniline) is formed when they are mixed (Fig. 5).

Atomic absorption spectrophotometry has indicated that the precipitate contains iron, which may be the reason for the orange coloration of the dentin [Marchesan, 2007]. Presence of parachloroaniline, which may have mutagenic potential, has also been demonstrated in the precipitate [Basrani *et al*., 2007; Basrani *et al*., 2009]. CHX and EDTA immediately produce a white precipitate when they are mixed (Fig. 6). Although the properties of the mixture and the cleared super natant have not been thoroughly studied, it seems that the ability of EDTA to remove the smear layer is reduced. Many clinicians mix NaOCl with hydrogen peroxide for root canal irrigation. Despite more vigorous bubbling, the effectiveness of the mixture has not been shown to be better than that of NaOCl alone [Heling, 1998]. However, combining hydrogen peroxide with CHX in an *ex vivo* model resulted in a considerable increase in the antibacterial activity of the mixture compared with the components alone in an infected dentin block [Heling, 1998; Steinberg *et al*., 1999].

Figure 5 A brownish-orange precipitate formed by mixing chlorhexidine with sodium hypochlorite.

Figure 6 A white precipitate formed by mixing chlorhexidine with EDTA.

Newer irrigation devices, techniques and solutions

Ultrasound in endodontic irrigation protocol

The use of ultrasonic energy for cleaning the root canal and to facilitate disinfection has a long history in endodontics. The comparative effectiveness of ultrasonics and hand-instrumentation techniques has been evaluated in several earlier studies. Ultrasound is a vibration or acoustic wave of the same nature as sound but at a frequency higher than required for production of ultrasound. This phenomenon uses magnetostriction that converts electromagnetic energy into mechanical energy. The other method is based on piezoelectric principle which uses a crystal that changes size when electrically charged. When crystals gets deformed, mechanical oscillation occurs without heat production [Plotino, 2007].The benefits of ultrasonic tip are that it delivers safety, control and high cutting efficiency without getting rotated. Ultrasounds eliminates smear layer, which appears less effective in improving EDTA activity [Plotino, 2007]. The effectiveness of irrigation depends on stream action and the chemical ability of the irrigants to dissolve tissue. With syringes, stream action is relatively weak and depends on both root canal anatomy and the depth of the needle according to its diameter. It has been shown that irrigants can only progress 1 mm beyond the tip of the needle. Increased volume does not significantly improve cleaning action or detritus elimination [Al-Jadaa *et al*., 2009]. Ultrasonic activation of irrigants produces at least two helpful effects:

Cavitation, defined as the formation of thousands of tiny bubbles which rapidly implode, producing a "shock wave" removing biofilm.

Acoustic streaming, which produces shear forces that will help extricate debris from instrumented canals.The amount of debris was significantly less in PUI irrigated root canals than in hand irrigated root canals. For PUI irrigated canals the amount of debris was 95% less than in untreated canals and for hand irrigated canals the amount of debris was 67% less than in untreated canals. PUI removed significantly more pulp tissue and dentine debris from the apical root canal than hand irrigation. PUI is a more effective irrigation system than hand irrigation in vitro and in vivo [Abou-Rassand Piccinino, 1982; Van der Sluis *et al*., 2006; Van der Sluis *et al*., 2007].

***Self -Adjusting File* (SAF)**

The SAF is the first file that does not have a solid metal core. The file is designed as a hollow tube, in which the walls are made from a thin nickel-titanium lattice with a rough outer surface. The tube has an asymmetrically positioned tip. The tip is located at the wall of the tube, as opposed to the symmetrically centered tips that may be found in all conventional nickel-titanium rotary files. The file is extremely compressible, such that a 1.5 mm SAF diameter may be compressed into a root canal that only a #20 K file can be inserted into. This compressibility also enables the file to adapt to the shape of the cross section of the canal. [Basrani, 2015].

Endo Vac System

The EndoVac system is a novel new irrigation system. It is based on a negative-pressure approach whereby the irrigant placed in the pulp chamber is sucked down the root canal and back up again through a thin needle with a special design [Gu *et al*, 2009]. A delivery/evacuation tip is attached to a syringe of irrigant and the high speed suction of the dental chair. A small tube attaches either a macro- or microcannula to the suction. The delivery/evacuation tip places irrigant in the chamber and siphons off the excess to prevent overflow. The microcannula is stainless steel and has 12 small, laterally positioned, offset holes in 4 rows of 3, with a closed end measuring ISO size 32.As these cannulas are placed in the canal, negative pressure pulls irrigant from a fresh supply in the chamber, down the canal to the tip of the cannula, into the cannula, and out through the suction hose. The microcannula can be used at working length in a canal enlarged to ISO size 35 or larger. The EndoVac delivery/evacuation tip was placed above the access opening to constantly deliver and evacuate 5.25% sodium hypochlorite (NaOCl), keeping the canal and pulp chamber full of irrigant at all times. One milliliter of NaOCl was used to replenish the irrigant in the pulp chamber after each rotary NiTi instrument. After reaching working length with the master apical file, macroirrigation of each canal with NaOCl was accomplished over a 30-second period. This was done by using the EndoVac delivery/evacuation tip while the microcannula was constantly moved up and down in the canal from a point where it started to bind to a point just below the orifice - negative pressure irrigation [Brunson *et al*., 2010]. One of the main purposes of the microcannula is to remove as much debris as possible before the smaller microcannula is used, thus reducing material that may clog the microcannula. The chemical action of NaOCl and EDTA may help to dissolve both organic and inorganic debris clogging the holes of the EndoVac.

Ozonated Irrigants

Ozonated water or NaOCl: Ozone is a chemical compound consisting of three oxygen atoms (O_3–triatomic oxygen), a higher energetic form than normal atmospheric oxygen (O_2). Thus, the molecules of these two forms are different in structure [Baysanand Lynch, 2005].Ozone is a very powerful bactericidal agent that can kill microorganisms effectively. It is an unstable gas, capable of oxidizing any biological entity. It was reported that ozone at low concentration, 0.1 ppm, is sufficient to inactivate bacterial cells including their spores. It is present naturally in air and can be easily produced by ozone generator. When introduced in water, ozone dissolves rapidly and dissociates rather quickly. Although ozonated water is a powerful antimicrobial agent against bacteria, fungi, protozoa, and viruses, less attention has been paid to the antibacterial activity of ozonated water in bacterial biofilm and hence in root canal infection [Nagayoshi *et al*., 2004].

Endo Activator

EndoActivator: It is a new type of irrigation facilitator. It is based on sonic vibration (up to 10,000 *cpm*) of a plastic tip in the root canal. The system has 3 different sizes of tips that are easily attached (snap-on) to the handpiece that creates the sonic vibrations. The use of Endo Activator facilitates irrigant penetration and mechanical cleansing compared with needle irrigation, with no increase in the risk of irrigant extrusion through the apex [Mancini *et al*., 2013].

Chitosan

Chitosan is a naturallinear polysaccharide obtained by the deacetylation of chitin, which is found in crab and shrimp shells. Biocompatibility, biodegradability, bioadhesion and lack of toxicity of chitosan are of a great importance in dental medicine. Due to its high chelating ability for various metal ions in acidic conditions, it has been applied widely in the removal or recovery of metal ions in different industrial areas. The structure of chitosan is similar to that of extracellular matrix proteins, such as proteoglycans and glycosaminoglycan. Previous research demonstrated its ability to enhance the mechanical properties of dentin collagen and to reinforce collagen constructs [Gusiyska *et al.*, 2016]. Some studies showed that chitosan and their derivatives interacted with and neutralised matrix metalloproteinases (MMPs), which improved the resistance of dentin to degradation [Kim and Kim, 2006;Pashley *et al.*, 2004].The chitosan-based irrigants showed a satisfactory ability to remove the smear layer and open the dentin tubules for subsequent sealing of the root canal system [Gusiyska *et al.*, 2016]. Future studies should focus on determining the most appropriate concentration for maximum elimination of the smear layer and investigating the physical, chemical and biological properties of chitosan solutions to preserve dentin and prevent erosion.

CONCLUSION

There is no single irrigating solution that alone sufficiently covers all of the functions required from an irrigant. The goal of irrigation in root canal treatment is to improve the cleaning and disinfection process within the root canal system. At present, there are no irrigating solutions capable of removing both the organic and inorganic elements of the smear layer. Using a combination of products in the correct irrigation sequence and technique contributes to a successful treatment outcome. Future studies should focus on determining the most appropriate concentration for maximum elimination of the smear layer and investigating the physical, chemical and biological properties of newly solutions.

References

1. Abou-Rass M, Piccinino MV. The effectiveness of four clinical irrigation methods on the removal of root canal debris. Oral Surg Oral Med Oral Pathol. 1982; 54:323-328.
2. Al-Jadaa A, Paqué F, Attin T, Zehnder M. Necrotic pulp tissue dissolution by passive ultrasonic irrigation in simulated accessory canals: impact of canal location and angulation. Int Endod J. 2009; 42:59–65.
3. AyhanH, Sultan N, Cirak M. Antimicrobial effects of various endodontic irrigants on selected microorganisms. Int End J 1999: 32; 99-102.
4. Basrani B. Endodontic irrigation. Toronto: Springer International Publishing Switzerland, 2015.
5. Basrani B, Manek S, Sodhi R, *et al*. Interaction between sodium hypochloriteand chlorhexidine gluconate. J Endod 2007; 33:966–9.
6. Basrani B, Manek S, Fillery E. Using diazotization to characterize the effect ofheat or sodium hypochlorite on 2.0% chlorhexidine. J Endod 2009; 35:1296–9.
7. Baumgartner JC, Mader CL. A scanning electron microscopic evaluation of four root canal irrigation regimens. J Endod. 1987; 13:147–57.
8. Baysan A and Lynch E. The use of ozone in dentistry and medicine. Primary Dental Care, 12(2), 2005, 47–52.9.
9. Berutti T, Marini R, Angeretti A. Penetration ability of different irrigants into dentinal tubules. J. Endodon 1997; 23: 725-27.
10. Brunson M, Heilborn C, Johnson DJ, Cohenca N. Effect of apical preparation size and preparation taper on irrigant volume delivered by using negative pressure irrigation system. J Endod. 2010; 36: 721-4.
11. Byström A, Sundqvist G. Bacteriologic evaluation of the efficacy of mechanical root canal instrumentation in endodontic therapy. Scand J Dent Res 1981; 89:321-328.
12. Byström A, Claesson R, Sundqvist G. The antibacterial effect ofcamphorated phenol and calcium hydroxide in the treatment ofinfected root canals. Endod Dent Traumatol 1985; 1:170-175.
13. Buck R, Eleazer P, Staat T. In vitro disinfection of dentinal tubules by various endodontics irrigants. J. Endodon 1999: 25; 786-88.
14. Clegg MS, Vertucci FJ, Walker C, Belanger M and Britto LR. The effect of exposure to irrigant solutions on apical dentin biofilms in vitro. Journal of Endodontics, 32(5), 2006, 434–437.
15. Cruz-Filbo A, Sousa-Neto M, Savioli R, *et al*. Effect of chelationg solutions on the microhardness of root canal lumen dentin. J Endod 2011; 37:358-362.
16. Dai L, Khechen K, Khan S, *et al*. The effect of QMix, an experimental antibacterialroot canal irrigant, on removal of canal wall smear layer and debris. J Endod2011; 37:80–4.
17. De-Deus G, Zehnder M, Reis C, *et al*. Longitudinal co-site optical micrscopy study on the chelating ability of etidronate and EDTA using a comparative single-tooth model. J Endod 2008; 34:71-5.
18. Desai P, Himel V. Comparative safety of various intracanal irrigation systems.J Endod 2009; 35:545–9.
19. El karim I, Kennedy J, Hussey D. The antimicrobial effects of root canal irrigation and medication. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology and Endodontology 2007; 103 (4): 560–569.
20. Estrela C, Estrela CR, Barbin EL *et al*. Mechanism of action ofsodium hypochlorite. Braz Dent J 2002 13: 113-117.
21. Estrela C *et al*. Efficacy of sodium hypochlorite and chlorhexidine against Enterococcus faecalis—a systematic review. J Appl Oral Sci 2008; 16:364-8.
22. Gettlemen B, Messer H, ElDeeb M. Adhesion of sealer cements to dentine with and without the smear layer. J Endod. 1991; 17:15–20.
23. Goldman M, Goldman LB, Cavaleri R, Bogis J, Lin PS. The efficacy of several endodontic irrigating solutions: a scanning electron microscopic study: Part 2. J Endod. 1982; 8:487–92.
24. Grossman L, Meiman B. Solution of Pulp Tissue By Chemical Agent. J Amer Dent Ass; 1941, 28:223

25. Gu L, Kim J, Ling J, Choi K, Pashley D and Tay F. Review of contemporary irrigant agitation techniques and device. *Journal of Endodontics*, 35(6), 2009, 791–804.
26. Gusiyska A, Vassileva R, Dyulgerova E, Ilieva R, Mironova J, Gyulbenkiyan E. Scanning electron microscopy studies of root canal dentin irrigated with a chitosan-citrate solution: a preliminary report. IJSR 2016; 5(1):539-542.
27. Haapasalo M, Ørstavik D. In vitro infection and disinfection of dentinal tubules. J Dent Res 1987; 66:1375–9.
28. Haapasalo M *et al*. Irrigation in Endodontics. Dent Clin N Am 2010 54:291–312.
29. Heling N, Chandler N. Antimicrobial effect of irrigant combinations within dentinal tubules. Int End J. 1998: 31; 8-14.
30. Hottel T, El-Refai N, Jones J. Comparison of the effects of three chelating agents on the root canals of extracted human teeth. J. Endodon. 1999: 25; 716-17.
31. Hülsmann M, Heckendorff M, Lennon A. Chelating agents in root canal treatment:mode of action and indications for their use. Int Endod J 2003; 36:810.
32. Hülsmann M, Rödig T, Nordmeyer S. Complications during Root Canal Irrigation. Endod Topics, 16: 27, 2007.
33. Hülsmann M, Hahn W. Complications during root canal irrigation: literature reviewand case reports. Int Endod J 2000; 33:186–93.
34. Johnson WT, Noblett WC. Cleaning and Shaping in: Endodontics: Principles and Practice. 4th ed. Saunders, Philadelphia, PA, 2009.
35. Kim M, Kim S. Chitooligosaccharides inhibit activation and expression of matrix metalloproteinase - 2 in human dermal fibroblasts. FEBS Lett 2006; 580: 2661–6.
36. Lee LW, Lan WH, Wang GY. An evaluation of chlorhexidine as an endodontic irrigant. J Formos Med Assoc 1990; 89:491-7.
37. Lee SJ, Wu MK, Wesselink PR. The effectiveness of syringe irrigation and ultrasonicsto remove debris from simulated irregularities within prepared root canalwalls. Int Endod J 2004; 37:672–8.
38. Mader C, Baumgartner J, Peters D. Scanningelectron microscopic investigation of the smeared layer on root canal walls. J Endod 1984; 10:477–83.
39. Mancini M, *et al*. Smear Layer Removal and Canal Cleanliness Using Different Irrigation Systems (EndoActivator, EndoVac, and Passive Ultrasonic Irrigation): Field Emission Scanning Electron Microscopic Evaluation in an In Vitro Study. J Endod 2013; 39(11):1456–1460.
40. Marchesan MA, Pasternak Junior B, Afonso MM, *et al*. Chemical analysis of theflocculate formed by the association of sodium hypochlorite and chlorhexidine. Oral Surg Oral Med Oral Pathol Oral Radiol Endod2007; 103:103–5.
41. Meztger Z, Basrani B, Goodis H. Instruments, Materials and Devices. In pathways of the Pulp, 8th ed, Cohen S., Hargreaves K. Elseiver. 2010.
42. Nagayoshi M, Kitamura C, Fukuizumi T, Nishihara T and Terashita M. Antimicrobial effect of ozonated water on bacteria invading dentinal tubules. Journal of Endodontics, 30(11), 2004, 778–781.
43. Nielsen B, *et al*. Comparison of the EndoVac System to Needle Irrigation of Root Canals. J Endod 2007; 33(5):611-5.
44. Oksan T, Aktener BO, Sen BH, Tezel H. The penetration of root canal sealers into dentinal tubules. A scanning electron microscopic study. Int Endod J. 1993; 26:301–5.
45. Pashley D. Smear layer: physiological considerations. Oper Dent Suppl. 1984; 3:13–29.
46. Pashley D, Tay F, Yiu C, Hashimoto M, Breschi L, Carvalho R, *et al*. Collagen degradation by host - derived enzymes during aging. J Dent Res 2004; 83: 216–21.
47. Perez F, Calas P, RochdT. Effect of dentin treatment on in vitro root tubule bacterial invasion. J. Endodon1996: 82; 446-51.
48. Peters O. Current challenges and concepts in the preparation of root canal systems: a review. J Endod 2004; 30: 559-67.
49. Pitt Ford TR, Roberts GI. Tissue response to glass ionomer retrograde root fillings. Int Endod J. 1990; 23:233–8.
50. Plotino G, Pameijer CH, Grande NM, Somma F. Ultrasonics in endodontics: a review of the literature. J Endod. 2007; 33:81–95.
51. Senia ES, Marshal FJ, Rosen S. The Solvent Action of Sodium Hypochlorite On Pulp Tissue Of Extracted Teeth. Oral Surg.OralMed.Oral Pathol Oral Radiol Endod; 1971; 31(1):96-103.
52. Shiozawa A. Caracterization of reactive oxygen species generated from the mixture of NaOCI and H202 used as root canal irrigants. J Endod 2000: 26; 11-15.
53. Sleiman F, Khaled F. Sequence of Irrigation in Endodontics. Oral Health May 2005. http://www.oralhealthgroup.com/news/sequence-of-irrigation-in-endodontics/1000195686/&er=NA
54. Steinberg D, Heling I, Daniel I, *et al*. Antibacterial synergistic effect of chlorhexidine and hydrogen peroxide against Streptococcus sobrinus, Streptococcus faecalis and Staphylococcus aureus. J Oral Rehabil 1999; 26:151–6.
55. Sato I, Ando-Kurihara N, Kota K, Iwaku M, Hoshino E. Sterilization of infected root-canal dentine by topical application of a mixture of ciprofloxacin, metronidazole and minocycline in situ. Int Endod J. 1996; 29:118–24.
56. Shabahang S, Aslanyan J, Torabinejad M. The substitution of chlorhexidine for doxycycline in MTAD: the antibacterial efficacy against a strain of Enterococcus faecalis. J Endod2008; 34:288-90.
57. Sjogren U, Figdor D, Persson S and Sundqvist G. Influence of infection at the time of root filling on the outcome of endodontic treatment of teeth with apical periodontitis. International Endodontic Journal, 30(5), 1997, 297–306.
58. Stuart CH, Schwartz SA, Beeson TJ, *et al*. Enterococcus faecalis: its role in root canal treatment failure and

current concepts in retreatment. J Endod. 2006; 32:93-98.
59. Torabinejad M, ChoY, Khademi A, Bakland L, Shabahang S. The effect of various concentrations of sodium hypochlorite on the ability of MTAD to remove the smear layer. J Endod 2003; 29:233-239.
60. Van der Sluis LW, Versluis M, Wu MK, *et al*. Passive ultrasonic irrigation of the root canal: a review of the literature. Int Endod J. 2007; 40:415-426.
61. Van der Sluis LW, Gambarini G, Wu MK, *et al*. The influence of volume, type of irrigant and flushing method on removing artificially placed dentine debris from the apical root canal during passive ultrasonic irrigation. Int Endod J. 2006; 39:472-476.
62. Van der Sluis LW, Wu MK, Wesselink PR. The evaluation of removal of calciumhydroxide paste from an artificial standardized groove in the apical root canalusing different irrigation methodologies. Int Endod J 2007; 40:52–7.
63. Violich D, Chandler N. The smear layer in endodontics - a review. Int Endod J. 2010; 43:2–15.
64. White RR, Goldman M, Sun Lin P. The influence of the smear layer upon dentinal tubule penetration by plastic filling materials. Part 2. J Endod. 1987; 13:369–374.
65. White RR, Goldman M, Sun Lin P. The influence of the smear layer upon dentinal tubule penetration by plastic filling materials. J Endod. 1984; 10:558–562.
66. Williamson A, Cardon J, Drake D. Antimicrobial susceptibility of monoculture biofilms of a clinical isolate of Enterococcus faecalis. J Endod 2009; 35:95–97.
67. Yoshida T, Shinohara T. Clinical evaluation of the efficacy of EDTA solution as an endodontic irrigant. J. Endodon 1995: 21; 592-93.
68. Zehnder M, Söderling E, Salonen J, Waltimo T. Preliminary Evaluation Of Bioactive Glass S53p4 As An Endodontic Medication In Vitro.J Endod 2004;30(4):220-4.
69. Zehnder M, Schmidlin P, Sener B, *et al*. Chelation in root canal therapy reconsidered.J Endod 2005;31:817–20.
70. Zehnder M. Root canal irrigants. J Endod 2006; 32 (5):389–398.
71. Zhan K, Kim Y, Cadenaro M, *et al*. Effects of different exposure times and concentrations of sodium hypochlorite/ethylenediaminetetraacetic acid on the structural integrity of mineralized dentin. J Endod 2010; 36:105-9.

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