# Antimicrobial Irrigants in Endodontic Therapy - A Review

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***Abstract*: Microorganisms and their metabolites are intimately related to the etiology of pulp and periapical pathology. The removal/elimination of pulp remnants, microorganisms, and by-products are important for endodontic treatment success. An objective of endodontic treatment is removal of diseased tissue, elimination of bacteria from the canal system and prevention of recontamination. Disinfection of the root canal system, as part of endodontic therapy, by preparation and irrigation is a key in reducing the number of bacteria within the root canal and helping to control periapical disease.**

## Introduction

Eliminating bacteria from the root canal system of teeth is an essential stage in endodontic therapy. Dentists should be adequately informed and skilled in this vital aspect of endodontics. It is desirable for endodontics to be straightforward, cost-effective and predictable. An objective of endodontic treatment is removal of dead or necrotised tissue, elimination of bacteria from the canal system and prevention of recontamination. (1) Disinfection of the root canal system, as part of endodontic therapy, by preparation and irrigation is key in reducing the number of bacteria within the root canal and helping to control periapical disease. (2) Recent guidelines, (3) suggest single-use for all endodontic instruments. This further enforces the need for effective irrigation, as potentially more root canal therapy is likely to be carried out over a single appointment. Additionally, greater than ever patient expectation of success makes it essential to optimise the disinfection process during endodontic treatment. There is no evidence that directly correlates endodontic outcome with a specific type of irrigant used.

## Endodontic Microbes

Although around 500 species of bacteria have been identified in the oral environment, only a limited number of them have been found to colonise the root canal system. (4) This might suggest that the root canal system is a hostile and difficult environment for microbes to survive, and those that do survive may be difficult to eliminate. The majority of infective microbes within the root canal system are bacteria; however, fungi have also been identified. (5) The microbial flora within necrotic root canals depends on the stage of the infection. (6) Initially, the bacterial load may be facultative (ie those that can use dissolved oxygen or chemically derived oxygen for respiration and can live under aerobic or anaerobic conditions), as time progresses (over 3 months) and the consumption of oxygen within the root canal increases, about 90% of the microbial flora is obligate anaerobic bacteria (those that do not require oxygen to live). Micro-organisms can exist within the root canals, dentinal tubules, accessory canals, canal ramifications, apical deltas, fins and transverse anastomoses. (7) They are found within biofilms (structured communities encapsulated within a self-developed polymeric matrix and adherent to the root surface) or in planktonic form (drifting in a body of fluid). Microbes are difficult to culture and it is known that those within a biofilm are 1000 times more resistant to biocides than the same organisms in planktonic forms. (8) There is disagreement on the importance of removing the smear layer.

Microorganisms and their metabolites are intimately related to the aetiology of pulpal and periapical pathology. The removal or elimination of pulp remnants, microorganisms, and by-products are important for the success of endodontic treatment (9, 10)

The polymicrobial nature of endodontic infections is reported in the literature (11,12). Enterococcus faecalis and Candida albicans are likely candidates. Enterococcus faecalis, a Gram-positive bacterium commonly detected in persistent infections, has the capacity to deeply penetrate into dentine tubules and, thus, endures after use of bactericidal substances during endodontic treatment(13). Candida albicans is a versatile yeast, being able to adapt to different levels of pH and capable of proliferating on dentin surface and penetrating into dentin tubules (14).

Lipopolysaccharide (LPS), also known as endotoxin, is present in the outer cell membranes of Gram-negative bacteria and is released during cell division or death of the cell (15), being one of the most significant virulence factors involved in the development and maintenance of periapical inflammation and clinical symptomatology (16). Due to its toxicity to pulp and periapical tissues, special attention has been given to the complete removal/neutralisation of endotoxin from infected root canals. LPS from Escherichia coli (a facultative anaerobic straight rod-shaped Gram-negative bacteria), considered standard endotoxins, has been used to test the ability of different irrigants in reducing endotoxin (17). Root canals with complex anatomy limit the mechanical action of endodontic instruments, and, thus, the use of chemical solutions with antimicrobial activity, ability to dissolve organic tissues, lubricant properties, and low cytotoxicity is highly recommendable as an adjunct to the mechanical preparation.

### Sodium Hypochlorite

Sodium hypochlorite (NaOCl) is the most frequently recommended and a commonly used endodontic irrigant. Its advantages are two-fold; pulpal dissolution and antimicrobial effect. NaOCl is a strong base with a pH of 11 and acts as an organic solvent, which causes degradation of amino acid and hydrolysis through chloramine molecules production. (11) There is evidence to show that a decrease in microbial numbers is achievable when using NaOCl for endodontic treatment of teeth with apical periodontitis. (12) The smear layer is not removed in the process of irrigation by NaOCl. (2) NaOCl is easily available from a variety of sources from supermarkets to dental suppliers and in a variety of concentrations. When NaOCl is chosen, it must be remembered that the concentration and temperature of the solution has a bearing on its effectiveness. A concentration of over 0.5% is required to reduce bacterial load significantly. (13)In vitro evidence has implied that using NaOCl at a concentration of 0.5% for 10 seconds can reduce the bacterial load of A. naeslundi seen in untreated necrotic root canals and C. albicans which is found in endodontic failure cases, to below the limit of detection. It was found that a contact period of 30 minutes was required to reduce the bacterial load of E. faecalis below the limit of detection. At a concentration of 5.25%, 2 minutes of contact period was required to reduce the bacterial load. (14) NaOCl at a concentration of 5.25% heated to 20°C is as effective as NaOCl at a concentration of 1% heated to 45°C. NaOCl at a concentration of 1% heated to 60°C is significantly more effective than 5.25% at 20°C. (15)

### Iodine

Iodine was introduced into endodontics in 1979 advocating the use of povidone iodine, as it was seen to be an antiseptic against a broad range of micro-organisms, hypoallergenic, with low toxicity and has a decreased tendency to stain dentine. (16,17) Since then iodine has been shown to be bactericidal, fungicidal, tuberculocidal, virucidal and sporicidal. The collagen matrix in dentine can inhibit iodine. It is thought that iodine attacks key group proteins, nucleotides and fatty acids, leading to cell death. The advantage of iodine over the other irrigants is that 2% preparations of Iodine Potassium Iodide (IPI) used in endodontics are shown to be less irritating and toxic than Formocresol, Camphorated Monochlorophenol (FMCP), and Cresatin. It is also suggested that iodine at a concentration of 2% is faster at reducing the bacterial load than a calcium hydroxide inter-appointment dressing; 2%IPI needs 1–2 hours to prevent growth of E. faecalis.

### Chlorhexidine

Chlorhexidine (CHX) is a cationic bis-biguanide antiseptic. Its advantages are based on a broad spectrum of activity.
CHX attacks multiple sites at a cellular level, making resistance less likely. CHX is a positively charged hydrophilic and lipophilic molecule which interacts with phospholipids and lipopolysaccharides in cell membranes. Consequently, there is disruption of the cell membranes which allows CHX molecules to enter the cell to cause intracellular toxic effects, such as coagulation of the cytoplasm. CHX is bacteriostatic at low concentrations and at higher concentrations is bactericidal to both gram positive and gram negative microbes, with greater activity against gram positive bacteria. CHX at a concentration of 0.2% (Corsodyl, GlaxoSmithKline Consumer Healthcare, UK) is not very bactericidal. Chlorhexidine has a unique property in that it has substantivity, ie has a persistent residual antimicrobial action. It can theoretically prevent microbial colonisation for a period of time after the actual medication period. However, while the dentine is absorbing CHX in the first hour, it is not yet active and the dentine must reach a saturation point for there to be a persistent antimicrobial effect. CHX is unsuitable as an interappointment dressing, as there are issues of leakage which may increase the space available for recolonisation of microbes. Like many of the other irrigants, CHX is self limiting and antimicrobial substantivity depends upon the number of CHX molecules available for interaction with the dentine, and hence must be replenished frequently.

### EDTA

Ethylenediaminetetraacetic acid (EDTA) is a synthetic amino acid and the sodium salts of EDTA (Na2EDTA) are used in dentistry. It is often used as a chelating agent (substances with an ability to scavenge up and form ring-shaped internal complexes with metallic ions including calcium) and is non corrosive to instruments. EDTA is not bactericidal nor bacteriostatic but inhibits the growth of, and eventually kills, bacteria by starvation as metallic ions needed for growth are chelated thus are not available for use by micro-organisms. EDTA is relatively non toxic but is slightly irritating in weak solution. EDTA at concentrations of 15–17% removes calcium from dentine leaving a softened matrix of dentine. It also emulsifies soft tissue and removes the smear layer with no deleterious effect to pulpal or periapical tissues. The application of EDTA at a concentration of 17% for over 10 minutes has been shown to cause excessive erosion of peritubular and intertubular dentine.The suggestion is for EDTA to be in the root canal system 1– 5 minutes to achieve the desired effect. EDTA, like many other irrigants, is self-limiting. Frequent changing of the solution is more effective than one continuous application.

### Hydrogen Peroxide

Hydrogen peroxide (H2O2) is a colourless liquid and has been used in dentistry in concentrations varying from 1% to 30%. H2O2 degrades to form water and oxygen. It is active against viruses, bacteria, bacterial spores and yeasts via the production of hydroxyl free radicals which attack proteins and DNA. There is the rare but potential danger of effervescence with H2O2 and seepage into the tissues may lead to air emphysema.

### Conclusion

It must be kept in mind that the effectiveness of all irrigants has mostly been measured in vitro environments. More research that relates to endodontic success with irrigant types and methods used is required.

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