Indian Journal of Dental Sciences.
September 2012 Issue:3, Vol.:4

www.ijds.in

Review Article

Indian Journal
of Dental Sciences

E ISSN NO. 2231-2293 P ISSN NO. 0976-4003

Root Canal Irrigants And Irrigation Techniques - A Review Part 1

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Submission : 09th October 2011
Accepted : 08th June 2012

Quick Response Code

Abstract
Root canal irrigation is not much emphasised in endodontic therapy. Most articles discussed are on root canal shaping and obturation not much emphasis is given for irrigation. There are many irrigation solutions which are introduced into market. This has led to a great deal of confusion on the type of irrigants, the protocol and the method of use. The purpose of this article is to analyse root canal irrigants, irrigation techniques and irrigation protocol.

Key Words
Disinfection, EDTA, smear layer, sodium hypochlorite, root canal irrigants. Endodontic irrigants

Introduction

The aim of root canal treatment is to clean root canal by considering biological, chemical and mechanical objectives. The pulp space is colonised with different micro organisms and bacterial infection in pulp space and peri apical region and is one of the main causes for failure of root canal treatment[1]. Recently more stress is on mechanical objectives with less attention to biological objectives which is very important for success of root canal treatment. Control of infection is prime consideration in non surgical root canal treatment. The pulp space anatomy is complex with variations such as delta, fins, lateral and accessory canals. Mechanically reaching these areas and cleaning is impossible. Complete removal of micro organisms from root canal is very important for success of treatment.

The ideal requirements of irrigation solution: [2]

1. It should have broad spectrum of anti microbial activity.
2. It must aid in debridement of the canal system.
3. It should have the ability to dissolve necrotic tissue.
4. It should have low toxicity level.
5. It should be a good lubricant.
6. It should have low surface tension so that it can easily flow into inaccessible areas.
7. It should be able to effectively sterilize the root canal.
8. It should be able to prevent formation of smear layer during instrumentation or remove the latter once it has formed.
9. It should inactivate microbial toxins.
10. It should not corrode instruments.
11. Dissolve inorganic tissue.
12. Penetrate to canal periphery.
13. Do not weaken tooth structure.

Classification: I-Chemicals Agents, II-Natural Agents

I - Chemicals Agents

- **REDUCING AGENTS** - Sodium hypochlorite(NAOCL).
- **OXIDISING AGENTS** - Hydrogen peroxide(H2O2).
- **ANTI BATERIAL AGENTS** - Chlorhexidine gluconate(CHX), MTAD, Tetraclean, smearclear, Q-Mix.
- **CHELATING AGENTS** - HEPB, EDTA, MTAD, Tetraclean, smearclear, Q-Mix.
- **ACIDS** - maleic acid, citric acid, poly acrylic acid, HEBP.
- **COMBINATIONS** - MTAD, Q-Mix, Tetraclean, smearclear.
- **OTHER NEWER IRRIGANTS** : BDA solution, ruddles solution, electrochemically activated water, ozone water, salvizol, glyoxide.

II - Natural Agents - Propalis, Triphala, Meswak , Tree tea oil, Morinda Citrifolia, green tea polyphenols and Arctium Lappa.

1. Sodium hypo chlorite (NaOCL)

Sodium hypochlorite has been used as an Endodontic irrigant since 1920. NaOCL is the most popular and ideal irrigating solution as it covers most of requirements as endodontic irrigant but it is caustic to tissues and should be used with caution . During World War I, Chemist Henry Drysdale Dakin used 0.5% NaOCL solution to clean infected wounds[3]. Various concentrations ranging from 0.5% to 5.25% have been tried out. Best regimen is reported with 5.25% for 40 minutes[4] 1%-3% is ineffective against e fecalis at the same time[5]. NaOCl when mixed in water ionizes 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.[6] Hypochlorous 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.[7,8]

Methods to improve the efficacy of NaOCL

Heating : A raise in temperature of 25 degree[9] is found to increase efficacy by 100% but temperature required to

dissolve pulp at 1%concentration is 450 and 5.25% is 20 degree[10]

Ultra Sonics : Ultrasonics significantly improves the efficacy of NaOCL irrigation. When a small file (mostly#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 hand piece 1mm short of the working length, the canal should be enlarged apically at least to a size 25.5% NaOCL is effective in cleaning apical third of canal by ultra sonic aggitation[10]

Altering PH-avoid dilution : The anti bacterial and tissue dissolving properties of 5.25%NaOCL decreases on dilution11, 12 Researchers have found that 5.25%, 2.5%, and 1.0% solutions of sodium hypochlorite completely removed pulpal remnants and predentin from uninstrumented surfaces of root canal. Others reported that either 5.25% or 2.5% sodium hypochlorite has the same effect when used in the root canal space for a period of 5 minutes. Effectiveness of lower concentrations of NaOCL may be improved by using larger volumes of irrigant or leaving the irrigant in the canals for longer periods of time.

Disadvantages of sodium hypochlorite

-Unpleasant taste

-Tissue toxicity- 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 of solution into oral tissues. Forceful extrusion of NaOCL into the periapical region can cause a severe inflammatory reaction.

-Inability to remove smear layer

-Allergy

The efficacy of sodium hypochlorite, as an antibacterial agent, is increased when it is used in combination with other solutions, such as:

- Calcium hydroxide,
- EDTAC, or
- Chlorhexidine

2. Hydrogen peroxide (H2O2)

Hydrogen peroxide (H2O2) is an irrigation solution. It is highly unstable and easily decomposed by heat and light It is an active agent that affects a wide range of organisms such as bacteria, yeast, fungi, viruses and spores[13]. The antibacterial effect of H2O2 involves hydroxyl radicals. The hydroxyl radical, being a potent oxidant, can react easily with macromolecules such as membrane lipids and DNA thus resulting in bacterial death[13]. The mechanism of action of hydrogen peroxide (HP) involves the reaction of superoxide ions to produce hydroxyl radicals which can attack membrane lipids, DNA and other essential cell components [14]. Heling & Chandler in a study on extracted bovine incisors reported that 3% HP required 10 minutes to eliminate E. *faecalis*. In the present study, 3% HP produced 33.3%negative cultures of E. *faecalis* after 5-minute exposure period indicating that 5-minute exposure period is not enough for exhibiting satisfactory antibacterial effect. It is advisable to use NAOCL after H202 use as nascent oxygen from h202 causes pressure build up and pain on closing tooth[14].

3. Chlorhexidine digluconate (CHX)

CHX is widely used for disinfection in dentistry because of its good antimicrobial activity. It has gained considerable popularity in endodontics as an irrigating solution and as an intra canal medicament.CHX does not possess some of the undesired characteristics of sodium hypochlorite which includes bad smell and strong irritation to periapical tissues. However, CHX has no tissue-dissolving capability and therefore it cannot replace sodium hypochlorite[15]

Properties Of Chlorhexidine

Mechanism of action of chlorhexidine : Its action is the result of adsorption of chlorhexidine on the cell walls of microorganisms, resulting in a leakage of intracellular components. CHX binds electro statically to negatively charged phosphate sites on bacterial cell wall16 by attaching to the bacterial cytoplasmic membrane and damaging the cell membrane, CHX causes the osmotic balance to be lost, resulting in leakage in intracellular constituents resulting in leakage and thus creating biphasic effect on membrane permeability. CHX can displace the calcium that is bound to sulfated glycoprotein of dental plaque. This explains the property of substantivity of CHX. The anti bacterial activity of CHX is pH dependent and the optimal range is 5.5 to 0.7. [17]

Anti bacterial activity : Chlorhexidine inhibits the gram-positive and gram-negative microorganisms commonly found in endodontic infections. CHX gel and liquid forms of 0.2%,1% and 2% were compared with 0.5%,1 %,2.5%,4%, 5.25% of NaOCL and it was concluded 2% liquid forms both eliminated S.Aureus and Candida Albicans in 15 seconds and 2% gel form killed E fecalis micro organisms in one minute both the irrigants eliminated porphyromonas organisms in 15 seconds [18,19] CHX has cationic properties, it can bind to surfaces covered with acidic proteins, such as the hydroxyapatite component of dentin, and be released at therapeutic levels, a phenomenon known as substantivity[20].

Cytotoxicity of CHX : CHX is minimally toxic to host tissues and does not cause any long-term damage to host tissues; it still may cause an inflammatory response in the tissues if expressed beyond the apical constriction. Reactions such as small foci of tissue necrosis, apoptosis of the fibroblast and inflammatory responses and tissue death have been correlated with the concentration of chlorhexidine used.[21]. Chlorhexidine forms para-chloranaline (PCA), which is an aromatic amine. Studies on rats, rabbits, and cats, have shown to have the primary toxic effect because of methemogloblin formation which on repeated exposures to PCA led to cyanosis and methaemoglobinaemia formation. Exposure to PCA in humans, produced symptoms of increased in methemoglobin and sulfhaemoglobin levelsleading to cyanosis, development of anemia, and anoxia changes. While chlorhexidine may spontaneously hydrolyze to PCA over time , it undergoes a chemical reaction when combined with NaOCl and forms a precipitate that contains PCA .irrigants such as water can be used to flush NaOCl from the canal before chlorhexidine is used, thus minimizing PCA formation.Irrigation combined with Ethylene dia minetetraacetic acid (EDTA) may be used to flush the remaining NaOCl out of a canal, as the combination of chlorhexidine and EDTA does not result in a chemical reaction.

Chelating Agents

It is defined as a chemical which combines with metal to form chelate.

Chelating Agents: EDTA, CITRIC ACID, POLY ACRYLIC ACID,

MALEIC ACID, HEBP

EDTA - is the most common chelating agent introduced into dentistry by Nygaard Ostby for smear layer removal. It is used for lubrication, emulsification and to hold debris in suspension. It contains four acetic acid groups attached to ethylenediamine. It is non toxic, least irritating in weak solutions. Action of EDTA depends on the concentration and time it is in contact with dentine tissue. It is mostly used with pH of 7.3 and concentration of 15- 17%. It is reported that EDTA can decalcify dentine up to a depth of 20-30µm in 5 min.[22]. Continuous rinse of 17% EDTA for 3 min completely removes smear layer from root canal walls[23] EDTA used in Ultra Sonics in of concentration of 17% is effective in removing smear layer at apical region of root canal.[24] EDTA combined with Sodium hypo chlorite has been reported to perform better in smear layer removal and opening the dentinal tubules[25]. EDTA alone does not have anti microbial property[26] hence it is combined with other irrigating agents to reduce intra radicular flora.

Commercially it is available As

EDTA, EDTAC-EDTA +CETAVELON quaternary ammonium compound, RC PREP-EDTA+ Urea peroxide & carbo wax, GLYDE, FILE-EZE

CITRIC ACID

It can be used alone or in combination with EDTA. Concentrations ranging from 1-40% have been used in endodontics to remove smear layer after root canal preparation.10% citric acid removes smear layer and has anti microbial action [27]. Citric acid should not be used with sodium hypochlorite as it interacts with NaOCl and reduces the available chlorine making it ineffective against microorganisms. Poly acrylic acid and 7% malic acid may also be used to remove smear layer[28]. HEBP-1-Hydroxy ethylidene 1,1- bisphosphonate also known as Etidronate or etidronic acid has been suggested as an alternative to EDTA and citric acid, as it has short term reaction with NAOCL and is non toxic to tissues. Studies have found that action of 18% of HEBP is comparatively much slower when compared with 17% EDTA[29].

MTAD : MTAD was developed by Torabinejad M for removal of smear layer and has anti microbial property. MTAD is a mixture of 3% doxycycline, 4.25% citric acid and detergent (Tween80)[30]. This acts synergistically against bacteria. Citric acid removes smear layer and allows doxycycline to enter dentinal tubules and exert anti bacterial effect. It is advised MTAD to be used as final rinse for 5 min following use of NaOCl[31]. MTAD (Biopure, Tulsa Dentsply,Tulsa, OK, USA) and Tetraclean are new combination products for root-canal irrigation . MTAD and Tetraclean are designed primarily for smear-layer removal with added antimicrobial activity.

Q-MIX : A newer irrigant developed by Dr.Markus Haapasalo et al,UBC,Canada ,which is recommended for final rinsing of root canal. This irrigant eradicates bacteria, removes smear layer and persists in bio films[32]. It contains ethylenediamine tetraacetic acid (EDTA), Chlorhexidine and cetrimide (N-Cetyl-N,N,N-TriMtehylAmmonium Bromide) mixed in distilled water with acceptable additional salt.

NEWER IRRIGANTS:

Electro Chemically Activated Water:

Electrochemically Activated (ECA) Solutions are produced from tap water and Low-concentrated salt solutions[33]. The ECA technology represents a new scientific paradigm developed by Russian scientists at the All-Russian Institute for Medical Engineering (Moscow, Russia, CIS). Electrochemical treatment in the anode and cathode chambers results in the synthesis of two types of solutions, that produced in the anode chamber is termed an Anolyte; and that produced in the cathode chamber is Catholyte. Anolyte solutions containing a mixture of oxidizing substances demonstrate pronounced microbicidal effectiveness against bacteria, viruses, fungi and protozoa[34]. Anolyte solution has been termed Super-Oxidized Water or Oxidative Potential Water [35]. Depending on the type ECA device incorporated the FEM elements the pH of anolyte varies; it may be acidic (anolyte), neutral (anolyte neutral) or alkaline (anolyte neutral cathodic); acidic anolyte was used initially but in recent years the neutral and alkaline solutions have been recommended for clinical application.

Advantages: Both types of ECA solutions (anolyte and catholyte) have been reported to be effective for the treatment of cutaneous and mucous infections as well as for posttraumatic and postoperative suppurative complications, and purulent surgical diseases. ECA solutions are recommended for use in lesion and wound irrigation or dressing. ECA solutions demonstrated more pronounced clinical effect and were associated with fewer incidences of allergic reactions compared to other antibacterial irrigants.

Ozone Water : Ozone is one of the most powerful antimicrobial agents available for use in medicine and dentistry. Ozone has been proposed as a dental antiseptic agent based on reports of its antimicrobial effects in both gaseous and aqueous forms. It is powerful anti microbial agent against bacteria, fungi, protozoa and viruses.[36]Ozone is effective when it is prescribed in sufficient concentration, used for an adequate time, and delivered correctly into root canals after the traditional cleaning, shaping, and irrigation have been completed. Ozone will not be effective if too little dose of ozone is delivered or it is not delivered appropriately. Ozone should be used after the conventional cleaning, shaping, and irrigation of root canals, and the ozonated liquid in the canal system should be agitated with ultrasound.

Advantages : Ozone is an effective, easy, cheap, and fast treatment to help disinfect root canals. It is the most powerful antimicrobial and oxidant we can use in endodontics.

Conclusion

Irrigation and irrigation solutions have a key role in successful endodontic treatment. Many factors should be considered when choosing an irrigant for endodontic therapy which include, antimicrobial activity, effect on bonding properties, toxicity, and the ability of the irrigant to dissolve tissue. Detailed understanding of the mode of action of various root canal irrigation solutions is important for optimal irrigation. Use of single irrigant alone does not fulfil all requirements of irrigation.There is no single irrigating solution that alone covers all the functions required from an irrigant.Recently use of combinations of irrigant, in a specific sequence has become popular as it fulfils all requirements and provides safe and effective irrigation.

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Source of Support : Nill, **Conflict of Interest** : None declared