REVIEW ARTICLE

ANTIMICROBIAL SOLUTIONS USED FOR ROOT CANAL DISINFECTION

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SUMMARY

This article discusses the significance of root canal disinfectants and comments on how these can be used professionally. The complex root canal system is inhabited with different microbes in periapical periodontitis. There is no particular disinfectant that alone satisfactorily fulfills the entire functions essential for irrigation. Best possible irrigation is found on the combined use of two or more disinfectant, in a particular sequence.

Sodium hypochlorite is the most commonly recommended endodontic irrigant, in spite of some adverse reactions. Chlorhexidine, Iodine and Chelators are successful against several bacteria and viruses, mainly in retreatment cases. Newer root canal irrigants like MTAD (Mixture of Tetracycline, Acid and Detergent), Tetraclean, Photo-activated disinfection, Electronically Activated Water, Ozonated water and lasers have potential to maximize root canal disinfection. Currently these newer irrigants could be used as an adjunct to NaOCl, while investigators are continuously looking for the subtle ideal root canal irrigant.

Key Words: *Root canal disinfectants, sodium hypochlorite, chlorhexidine, chelators, iodine, photo-activated disinfection.*

INTRODUCTION

The goal of endodontic management is elimination of necrotic tissue, bacteria from the root canal system and avoidance of re-infection.[1] Disinfection of the root canal organization, is an essential component of endodontic therapy during preparation and irrigation, in decreasing the bacterial load and aid to control periapical infection.[2]

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Removal of microorganisms from contaminated root canals is a complex job.[3] The probabilities of a favorable result with root canal healing are high, if infection is eliminated successfully before obturation of the root canal structure.[4] Though, if microbes are there at the period of obturation, or if they enter into the canal following obturation, there is increased threat of management failure.[1,4] Current guidelines, recommend single-application for all endodontic apparatus.[5] This makes compulsory the requirement for efficient antimicrobial solution, when root canal treatment is to be carried out more than a single visit. Moreover, greater expectations of patient for success of endodontic therapy make it important to optimize the disinfection method throughout endodontic management.[6]

Numerous endodontic 'solutions' available that can be classified as lubricants, irrigants and intracanal medicaments.[7] The use of antimicrobial agents throughout instrumentation to clean all part of the root canal

structure is essential to successful endodontic healing.[1] Irrigation is paired to instrumentation provide support in the elimination of pulp tissue and microorganisms.[7] The efficacy of endodontic solution depends on the functioning method of the irrigant and the ability to carry the antimicrobial solution in contact with the microorganisms and tissue fragments in the root canal.[8] Disinfection and preparation of the root canal system effectively to allow the host response to be turn toward the healing of the periapical tissues.[3] The complicated root canal system has accessory features, microbes can survive within the root canals, dentinal tubules, accessory canals, canal ramifications, apical deltas, and fins, once the tooth become infected.[5] The greater component of infective microorganisms inside the root canal system are bacteria though fungi, spirochaetes, and viruses have also been colonized.[4] In the beginning, the bacterial load may be facultative, (require oxygen to live) since over 3 months 90% obligate anaerobic bacteria (those that do not need oxygen to survive).[7] They are existed within biofilms (planned communities encapsulated within a self-developed polymeric matrix and adherent to the root surface) or in planktonic shape (migrant in the body of fluid).[9]

These microorganisms are structured into protecting adhesive biofilms which in addition to the anatomical difficulty of the root canal system, make root canal disinfection difficult but not impossible.[10] Primary infections contain gram-negative anaerobic bacteria plus fungi. Secondary cases have microbial classes such as Enterococcus-faecalis and Candida-albicans.[4] Enterococcus-faecalis is the most commonly found in retreatment cases and they can stay alive in harsh atmosphere with very alkaline pH.[5]

Currently no comprehensive guidelines on the use of endodontic irrigant are published by the British, the European and the American Endodontic Society. Therefore there is no conformity on which irrigant is most excellent and whether they should be used alone or in combination but it is decided that the irrigant must have bactericidal function.[11]

This article describes different types of antimicrobial irrigants, their action, and how these can be used most successfully. It also reviews current agents use to disinfect root canal.

ENDODONTIC SOLUTIONS

They are classified into Non-bactericidal and Bactericidal irrigants.

Non-bactericidal irrigants

Few dental clinicians use saline, local anaesthetics and distilled water as an irrigant in root canal system, but they have no antimicrobial action and will not decrease bacterial load considerably. These irrigants may be used often as they are safe, simple to apply and easily available.[11]

Bactericidal irrigants

Sodium hypochlorite

Sodium hypochlorite is well-known as 'gold standard irrigant' because it has all desired properties needed in irrigation.[12] Hypochlorite is the most commonly recommended endodontic irrigant.[1,2,12] It has been used in medical fields since the commencement of 20th century and was introduced as a part of endodontic therapy in 1936 by Walker.[5,13]NaOCl is an organic solvent (pH>11) cause amino acid degradation and hydrolysis through the production of chlorine.[1] It is capable in dissolving organic components, necrotic tissues, but its ability to remove inorganic components is inadequate.[5] NaOCl has a wide antimicrobial spectrum against bacteria, bacteriophages, spores, yeasts and viruses[13] but is not able to remove smear layer.[8] At higher concentrations it is capable to disinfect E.faecalis contaminated canals.[12] There has been disagreement over the concentration of NaOCl to be used in root canal. A range of concentrations of hypochlorite from 0.5% to 5.25% have been tested. In vitro research has revealed that using NaOCl at a concentration of 0.5% for 10 seconds can decrease the bacterial load significantly.[14] Other studies have demonstrated that a concentration of 5.25% NaOCl can eradicate E.faecalis and C.albicans within 15–30 seconds.[12,25] It is evident from the recent available facts that there is no justification for using NaOCl at concentrations higher than 1% as this achieves the desirable clinical effects.[11,13] Another study has shown that warming of NaOCl improve its effectiveness.[8] Sirtes et al described that 1% solution at 45 °C has the same outcome as 5.25% at 20 °C.[15] Still, there are no clinical studies in favour of these findings and additionally, it is unknown what

result this heat has on adjoining tissues. Another way of increasing the temperature of NaOCl is with acoustic micro-streaming caused by ultrasonic activation.[6,8] Ultrasonic activation of sodium hypochlorite increases the chemical reaction, generate cavitational effects and accomplish better cleansing action and remove more organic and inorganic debris from dentin shavings plus microbes.[15]

Sodium hypochlorite is caustic in nature, so various adverse reactions with it have been published in the literature like irritation, tissue damage risks if NaOCl is expressed under pressure into the periodontal ligament space and also reduce in flexural strength of dentin.[32] In order to lessen complications during endodontic procedure, vital precautions should be taken.[11]

Chlorhexidine

Chlorhexidine was developed by research laboratories of Imperial Chemical Industries Ltd in the late 1940s.[16] It is a bis-biguanide which carries a positive charge.[17] The antibacterial effect of chlorhexidine relates to its positive charge, which is quickly attracted to the negatively charged bacterial cell wall and increase permeability of bacterial contents.[16] Chlorhexidine action on the bacterial cell wall is bacteriostatic when it is used at low concentrations.[2] At higher concentrations, chlorhexidine shows bactericidal effect which cause coagulation and precipitation of the cytoplasmic apparatus.[11] CHX is more efficient against gram positive microbes and thus can have a function as a root canal irrigant in retreatment cases. In vitro studies have shown, it is useful against C-albicans and E-faecalis.[7]

As irrigant at 1% and 2% concentrations was revealed to be as quick as 5.2% NaOCl in eradication of E-faecalis in root canals.[17] Zamany et al demonstrated that 2% concentration is best for endodontic purpose.[18] CHX does not have the capability to dissolve organic tissue and so is less efficient in eliminating necrotic pulps but it is less toxic than sodium hypochlorite.[19] Chlorhexidine cannot be used as the main irrigant in endodontic cases, for the reason that (a) chlorhexidine is not capable to dissolve necrotic tissue (b) chlorhexidine is less successful on Gram-negative than on Gram-positive microorganisms.[17,31]

Iodine

Iodine was introduced into endodontics in 1979, povidone iodine is observed to be an antiseptic against a wide range of microbes.[20] Iodine has been revealed to be bactericidal, fungicidal, tuberculocidal, virucidal and sporocidal and degrades proteins, nucleotides and fatty acids, leading to cell death.[11]The benefit of iodine over other irrigants is that 2% preparations of iodine potassium iodide use in endodontics are shown to be less irritating and poisonous, but more rapidly reducing the bacterial load than a calcium hydroxide interappointment dressing.[1,11] At 2% concentration IKI needs 1–2 hours to stop development of E-faecalis and C-albicans which are frequently correlated with persistent endodontic disease.[20]

Iodine is known for its capability to penetrate all the way through dentinal tubules and destroy bacteria, though the period of its antimicrobial action is short.[2] It has been revealed that 5 min irrigation with 5% IKI lessen the count of E-faecalis found in root canals in cases of chronic apical periodontitis.[11] Iodine is also antiviral and viruses have recently been discovered in the pathogenesis of periapical infection. It is important that it is not used in patients reported allergy to iodine or seafood. Another problem with the use of iodine as irrigant, it has the possibility to stain dentine.[20]

Hydrogen peroxide

Hydrogen peroxide is used in endodontic between 3% to 5% concentrations.[21] It is active against bacteria, bacterial spores, viruses and yeasts by the production of free radicals which degrades numerous cell components such as proteins and DNA.[22]

The antibacterial action and tissue dissolving capability of H_2O_2 are very low than NaOCl, it has been revealed that NaOCl, combined with H_2O_2, is not effective against E-faecalis than NaOCl alone but CHX combined with hydrogen peroxide has better antibacterial action than each one on their own.[6] The modern evidence does not advocate the use of hydrogen peroxide over other irrigants.[11]

Chelator solutions

In endodontics, chelating agents were introduced by Nygaard Ostby in 1957.[23] Hypochlorite do not

remove the smear layer, thus demineralizing agents such as Ethylenediaminetetraacetic acid (EDTA) and citric acid have been suggested for absolute removal of smear layer during root canal treatment.[19,24]

EDTA

Ethylenediaminetetraacetic acid is a non toxic, artificial amino acid with a pH 7. It is used at concentrations of 17% as a root canal irrigant in both primary and secondary cases.[24] In vitro studies have proved, it is biocompatible but has no antibacterial effect. It restrains the growth and finally kills microbes by chelating with metallic ions needed for growth of bacteria.[23]

EDTA at concentrations of 15–17% eliminates calcium from dentine leaving an organic matrix of dentine. It also removes the smear layer with no lethal effect to pulpal or periapical tissues.[30] It was suggested that application of EDTA in the root canal system for 1–5 minutes enough to get the expected effect.[24] When EDTA is applied in combination with NaOCl, both the inorganic and the organic components are detached, get patent dentinal tubules and clean surfaces. EDTA interact with NaOCl and this can decrease the amount of available free chlorine, so influence the tissue dissolving ability and antimicrobial outcome of NaOCl.[31] In an alternating irrigating plan, abundant amounts of NaOCl should be used to clean out leftovers of the EDTA.[15] The use of EDTA at a concentration of 17% for more than 10 minutes has been revealed to cause too much erosion of peritubular and intertubular dentine.[33]

Citric acid

Citric acid (10–50% concentration) is another demineralizing solution that is used in endodontic to eliminate the smear layer after root canal preparation.[19] Zehnder et al confirmed that the citric acid at 10% concentration was less toxic.[23] Citric acid like EDTA also intermingles with NaOCl, reducing the availability of chlorine and it effect on bacteria and organic tissue.[29] Most studies have not established a considerable differentiation between the chelation properties of citric acid and EDTA. Citric acid 10% as compared to 17% EDTA, seem to be more biocompatible and valuable in removing smear layer.[24]

MTAD (Mixture of Tetracycline, Acid and Detergent)

It was introduced in endodontic as a substitute to EDTA to eradicate the smear layer.[34] It is a combination of an antibiotic 3% doxycycline, a chelating agent citric acid and a detergent Tween 80.[23]

Citric acid in the MTAD Chelator, removes the smear layer permit the doxycycline to penetrate into the dentinal tubules and exert an antibacterial effect.[35] The suggested protocol for clinical use of MTAD is 1.3% NaOCl for 20 min followed by 5 min application of MTAD.[32] It does not seem too considerably change the structure of the dentinal tubules.[24]

Although a last wash with MTAD might have adversely affected the adhesion ability of sealers (resin based and calcium hydroxide based) to root dentin.[28] Davis et al[42] described, MTAD is more competent than 5.25% NaOCl against E-faecalis and Zhang et al also confirmed that MTAD has less toxicity than 5.25% NaOCl, and EDTA.[43] As this agent contains antibiotic from a tetracycline family, there may be risks of bacterial resistance, intrinsic staining of dentine, and sensitivity. Limited data is available for the application of MTAD over other conventional irrigants, such as NaOCl.[25]

Tetraclean

Tetraclean like MTAD is combination of an antibiotic, an acid and a detergent but the concentration of the antibiotic (doxycycline-50mg/ml), and the kind of detergent (polypropylene glycol) different from those of MTAD. It is highly effectual against both, anaerobic and facultative bacteria.[34]

It eliminates the smear layer and unlocks the dentinal tubule orifices. It has low surface tension which allows better penetration of the solution into the dentinal tubule.[2,26] In vitro studies proved, Tetraclean is more efficient than MTAD against E-faecalis.[36] Another study evaluated the antibacterial efficacy of 5.25% NaOCl, MTAD, and Tetraclean against E-faecalis, they found only the NaOCl could detach and eradicate the biofilm effectively although treatment of root canals with Tetraclean caused a high level of colonies detachment each time when compared with MTAD.[1,4,32]

Photo-activated disinfection (PAD)

Oscar Raab introduced the photo-activated therapy for the inactivation of microorganisms in endodontic management.[26] Photo-activated disinfection is the placement of a dye (Toluidine blue or Methylene blue) into the root canals which is then activated by lasers radiation emitted from a low power (100 mW) laser device, causing interference with microbial cell walls and following bacterial death.[27]

After normal irrigation, the canals are washed with sterile water and they are dried by sterilized paper points before the application of the PAD solution into the canals. The theory after this technique is that the photosensitizer molecules will attach to the membrane of the microorganisms, and then the irradiation with a precise wavelength coordinated to the absorption of the photosensitizer will direct to the formation of singlet oxygen, causing burst of the cell wall and death of the microbes.[28] The success against endodontic bacteria depends on the power, duration of contact, penetration of light into the tissues, and distance from tip-to-target tissue. The benefit of PAD is that the dye is only poisonous to bacteria and there are no side-effects to adjacent tissues.[11]

Leticia et al studied the antimicrobial effects of photo-activated disinfection with methylene blue or toluidine blue as an addition to instrumentation/irrigation of root canals contaminated with Enterococcus faecalis. The study discovered that PAD with either MB or TB may not apply an important supplemental effect to instrumentation/irrigation actions with regard to intracanal disinfection, until additional modifications in the PAD system are required prior to medical use is suggested.[28]

In the PAD method, the optical fiber was not accurately entered into the root canals, and so the light could not penetrate throughout the tooth structure. Therefore PAD might not be competent to achieve a 100% eradication rate in contaminated root canals. PAD can recently be deemed a valuable adjunct to conventional root canal management.[29]

Ozone

Ozone is found in nature consisting of three oxygen atoms, discovered in 1840. It is occurred in the environment either in gaseous form or as ozonated water.[37] It is known as an antiseptic, powerful oxidant and antibacterial agent. It is a strong oxidizer of cell walls and the cytoplasmic membranes of microorganisms, forming it a bactericidal, antiviral and antifungal agent.[38] It has been observed that it do not have the ability to differentiate between a variety of targets in the surroundings and bacteria, possibly influence the result of antibacterial management.[1,2]

Nagayoshi et al advocated that ozonated water had almost the same antibacterial action as 2.5% NaOCl in endodontic therapy, particularly when used with the ultrasonics.[38] Huth et al also informed the possible advantages of employing ozone in root canal management in high concentrations.[37] Another study evaluated the capability of ozone to eradicate an E-faecalis, observed that its antimicrobial effectiveness was not equivalent to that of NaOCl.[11] Estrela et al described, ozone have no antibacterial action against E-faecalis.[41] These results and others have reservations on the worth of ozone as an antimicrobial agent in endodontic diseases.

Electronically Activated Water

The ECW technology is a symbol of an innovative scientific paradigm introduced by Russian scientists.[39] Electronically Activated Water (EAW) is also recognized as Oxidative Potential Water. It is electrolyzed saline solution and usually utilized to remove microbial contamination and biofilm from dental units piping and tubing. It is able to disturb biofilms by reducing the adhering capability of bacteria to canal walls by generating a negative isotonic pressure.[41]

In endodontics, research advocated that EAW with the application of ultrasound provides a more reduction in microbial load. Marais and Williams demonstrated that ECA is less effectual antibacterial agent than 3.5% NaOCl.[40] Due to the decreased toxicity and tissue injuries related with these solutions, further research is required.

Lasers

Neodymium:yttrium-aluminum garnet (Nd:YAG) lasers have been recently introduced for disinfection in endodontic therapy and it was established that when there was direct contact to the laser, all root canal

systems were not entirely eliminated of bacteria and they were not superior than irrigation with NaOCl.[44] In vitro study showed that the application of a photosensitizing solution and laser was not competent to accomplish complete diminution in bacterial load, but 3% NaOCl was noticed to attain it.[42] It should be considered that it may not be easier to enter small and curved canal places with lasers. Another limitation of these systems, they are costly to purchase.

CONCLUSION

NaOCl is still the best available irrigant due to its capability to dissolve organic matter together with its broad antibacterial spectrum. Presently newer root canal irrigants could be used as an adjunct to NaOCl. Innovative improvement in the composition of the irrigating agent and mechanical system used for successful delivery of the solution in complicated areas of the root canal system will provide safe and effectual irrigation.

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