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Review Article

NOVEL ROOT CANAL IRRIGANTS: AN ENDODONTIC EXPERIENCE

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ABSTRACT:

Root canal therapy of a tooth relies on proper instrumentation, irrigation and obturation of the root canal. Debridement of the canal is the main step during treatment to completely eliminate the source of infection. Proper biomechanical preparation is initiated to shape the canal and remove the bacteria to prevent periapical infections. Root canal irrigants are used after the mechanical instrumentation is done, to eradicate the remaining debris out of the canal. Various irrigants have been used such as sodium hypochlorite, saline and chlorhexidine, just to name a few. Unfortunately, none of these irrigants meet the ideal requirements of today; hence, new developments have been introduced for the reduction of inflammation and infection. This review will shadow upon the various advancements established recently to fulfill the treatment goal of disinfection in the root canal.

Key words: biomechanical preparation, chlorhexidine, debridement, infection, sodium hypochlorite, saline.

INTRODUCTION:

Colonization of microorganisms leads to pathological alteration making it the ideal environment to harbor bacteria. Irrigants are used to flush out the bacteria by mechanical instrumentation. It is essential that complete elimination of the microbes is performed before obturation for the success of the root canal treatment. [(1)] Studies have shown that the causative agent for infection are anaerobic gram positive organisms as these type of bacteria are resistant to intracanal medicaments penetrating the dentinal tubules through the layers of the tooth.[(2)(3)]

A specific type of anaerobic bacteria has been obtained and investigated in endodontics called Entercoccus faecalis, having the most harmful effects to the periapical canal leading to endodontic treatment failure. [(4)(5)] Removal of the microbes gets difficult when complex anatomy of the tooth consists of irregular dentinal tubules and formation of the smear layer.[(6)] The prime objective of successful treatment involves of proper shaping and cleaning with correct obturation. Various irrigants used in the modern age have not fulfilled the requirements of an ideal cleaning system,

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hence new and improved ideas introduced are more compatible than the older ones. In this review through the journals and experiments studied, the following irrigants will be discussed that have improved the outlook in Endodontics in root canal therapy. [7]

Q M ix™ 2 in 1

Q mix is an irrigating solution used as a final rinse. It is a combination of Chlorhexidine with ethylenediamine tetraacetic acid also known as EDTA. It functions in (1) lubrication (2) emulsification (3) holding debris in suspension (4) smear layer removal; chlorhexidine is an antiseptic, which is used for plaque control in the oral cavity. Chlorhexidine is not promoted as the main irrigant because it is unable to dissolve necrotic tissue remnants and is less effective on gram- negative than on gram-positive bacteria. Hence, a grouping of chlorhexidine and EDTA is more efficient in reducing accumulation of microorganisms in root canal systems. The action of a surfactant is the ability to reduce the surface tension of the liquid and allow it to be a wetting agent and penetrate in the dentinal tubules for a faster reaction. Therefore, through the composition, Q mix is highly biocompatible and is as effective as 17% EDTA used alone in removing canal wall smear layers after the use of 5.25% NaOCl as the initial rinse. [9][10] It is also effective in killing E. faecalis and plaque bacteria in planktonic and biofilm culture. [11] QMix, 17% EDTA/2% CHX demonstrated the highest mean bond strength values in the coronal and mid- level parts of a tooth. [12] Hence, use of Q mix can promote flushing of debris during root canal treatment.

Plant extracts

The use of herbal alternatives as root canal irrigants has demonstrated to be advantageous. Many herbal extracts have been studied and proved to act as a natural remedy for the root canal. Enterococcus faecalis which is a dominant enterococcus species survives in the root canal as a single organism without the support of other bacteria causing bone resorption. Owing to the potential effects of commonly used irrigants like sodium hypochlorite and chlorhexidine, use of therapeutic plants has increased over the last few decades. Herbal or natural products have been used in dental and medical practice for thousands of years and have become even more popular today.

Propolis exhibits a wide range of biologic activities, including antimicrobial, anti-inflammatory, antioxidant, anesthetic and cytotoxic properties. Ethanol extract of propolis presents good properties for endodontic use, such as promoting bone regeneration and inducing hard tissue bridge formation in pulpotomies or pulp capping. Results of a study conducted in evaluating the antimicrobial effect of propolis, BioP ure MTAD, 5% sodium hypochlorite (NaOCl), and 2% chlorhexidine CHX on Enterococcus faecalis (E. faecalis) and Candida albicans (C. albicans) in vitro, appears that propolis is an effective intracanal irrigant in eliminating Candida albicans in low concentration than e. fecalis, but does have the efficacy to eliminate both the bacteria. [13] The anti- inflammatory property of propolis is due to the

presence of caffeic acid and phenethyl ester (CAPE). Another study conducted assessed the antimicrobial activity of two solutions of propolis (one in dimethyloxide and one in ethyl alcohol) in comparison with 0.3% sodium hypochlorite and 0.2% chlorhexidine gluconate**.** [(14)]This study inferred that both the formulations used of propolis were not effective in eliminating e. faecalis. This agent used alone is not as effective as other root canal irrigants but in combination gives the same results as the antimicrobial activity similar to sodium hypochlorite.

Morinda Citrifolia also known as NONI exerts a preventive action against cancer and due to the analgesic properties can be used to relieve pain. It has also been shown to contain scopoletin, which has anti- inflammatory and histamine-inhibiting effects, both of which are excellent for the promotion of smooth joint movement and arthritis. With the beneficial effects on the body, it helps in root canal therapy. MCJ followed by a final flush of 17% EDTA can be regarded as an effective solution on smear layer removal without any adverse influence on micro-hardness property of root canal dentin.[(15)] Morinda C itrifolia juice and $Ca(OH)_2$ has been compared on E.faecalis infected root canal dentin at two different depths and three intervals. It was concluded that it was effective against E. faecalis in dentin on extracted teeth.(16) It is also the first juice to be identified as a possible alternative to cancer other than the use of NaOCl as an intracanal irrigant.

Arctium lappa it is an invasive weed of high- nitrogen soils. Also known as burdock, it is used to increase urine flow, kill germs, reduce fever, and purify the blood. It is also used to treat colds, cancer, anorexia, gastrointestinal (GI) complaints, joint pain, gout, bladder infections, and complications of syphilis and skin conditions. Along with the therapeutic systemic effect, it is used is used as an irrigant acting against E.faecalis being biocompatible.[(16)]

Triphala is an herbal supplement derived from the fruit of three trees native to India. The fruits are dried, ground into a powder and blended as Ayurveda. Triphala is comprised of equal parts of three herbal fruits: Harada, Amla and Bihara. The first fruit is believed to promote digestion and treat acute and chronic constipation. The second is believed to increase gastric emptying and possess antimicrobial properties. The third is a source of protein, oils and linoleic acid, an omega-3 essential fatty acid. Studies done evaluating the antimicrobial efficacy of this ayurvedic supplement in comparison with MTAD, and 5% sodium hypochlorite against Enterococcus faecalis biofilm formed on tooth substrate resulted in Triphala and MTAD showed statistically significant antibacterial activity. [(17)] The use of herbal alternatives as a root canal irrigant might prove to be advantageous considering the several undesirable characteristics of NaOCl.

Green tea polyphenols are an herbal derivative from green tea leaves (Camellia

sinensis) containing antioxidant ingredients – mainly green tea catechins (GTC) – green tea and its derivatives. It is a traditional drink of Japan and China and is prepared from the young shoots of tea plant Camellia S inensis. The leaves from the tea plant contain polyphenolic components acting against microorganisms. The anti-oxidative properties of the leaves are due to the ability of the polyphenol. [18][19] GTPs have demonstrated antioxidant, anti-inflammatory and antimicrobial properties in numerous human, animal, in vitro studies. Green and black teas both contain flavonoids that inhibit the growth and activity of the bacteria associated with tooth decay. Tea also contains natural fluoride, which may be helpful in preventing dental caries. [16]

Tetraclean

This irrigant is a mixture of doxycycline (an antibiotic of the tetracycline group), citric acid and a surfactant. Citric acid acts as a chelating agent, assisted by a weak action of the antibiotic, while the surfactant should make its penetration in the root canal system easier. A study done evaluating the antimicrobial effect of MTAD, Tetraclean, Cloreximid, and sodium hypochlorite on three common endodontic pathogens concluded that MTAD and Tetraclean showed a high action against both, strictly anaerobic and facultative anaerobic bacteria. (17) Tetraclean is able to eliminate microorganisms and smear layer in dentinal tubules of infected root canals. S ince an ideal root-canal irrigant should have strong antibacterial properties and minimal cytoto xic effects on the host tissues, a study was conducted on the biocompatibility of the product end result discussed was that Tetraclean is less cytotoxic than other currently used endodontic irrigants. [20]

Chlor-Xtra, Hypoclean A, Hypoclean B

Three recently introduced sodium hypochlorite solutions were tested and studied. These solutions were modified and labeled as Chlor-Xtra, Hypoclean A, and Hypclean B. Chlor-Xtra consists of wetting agents, surface modifiers, and alkylating agents. Hypoclean comprises of sodium hypochlorite and detergents. The antimicrobial ability of the three modified sodium hypochlorite solutions in different concentrations was compared with different concentrations of chlorhexidine against enterococcus faecalis. The study resulted that the sodium hypochlorite solutions were more efficient in eliminating micro-organisms than chlorhexdine. [21] Another study was conducted comparing the ability of 5.25% solution of sodium hypochlorite with the modified solutions. The new 5.25% sodium hypochlorite solutions modified with surfactants, Hypoclean A and Hypoclean B, had surface tension values lower than Chlor-Xtra and 5.25% sodium hypochlorite. [22] Low surface tension is beneficial because the irrigant is then allowed to penetrate into the areas that have not been cleaned and increase contact with dentinal walls. Thus, eliminating bacteria and preventing pulp tissue destruction.

Silver nano particles

Nanomaterials are a field that takes a materials science-based approach on nanotechnology. Nanoparticles have to have at least one dimension that measures 100 nanometers or less. The particles have wide variety of potential applications in biomedical, optical and electronic fields. Recently, silver nanoparticles have been introduced in root canal therapy. It has been studied Based on the findings of an in vitro study, adding silver nanoparticles to Angelus white MTA enhanced its antimicrobial activity against E. faecalis, C. albicans, and P. aeruginosa**.** [(23)] In comparison to sodium hypochlorite and chlorhexidine, addition of silver nanoparticles in an irrigating solution will have favorable antimicrobial properties and once its other characteristics are proved safe, it can be used as an alternative to other canal irrigation solutions. ; hence, proving an effective irrigant in endodontics today making it biocompatible. [(24)]

Electro chemically activated solutions

Electrochemically activated solutions are produced from tap water and low concentration salt solutions. [(25)] This was first introduced in the Russian institute of Medical Engineering consisting of a technology with an anode and cathode. The principal of this is to transfer liquids into a metstable state through a reactor called “F low-through electrolytic module”. Electrochemical treatment results in synthesis of two types of solutions: anolyte and catholyte. The anolyte solutions have the capability of acting against bacteria and viruses because of the oxidizing xx effect. [(25)] In endodontics today, these solutions have a greater property of cleaning efficiently and being non-toxic to the tissues. Advantages of the solution are that it is non-toxic to biological tissues and effective with wide range of microbial septa. Irrigation with electrochemically activated solutions cleaned root canal walls and can be an alternative to NaOCl in conventional root canal treatment, but further studies are needed. An evaluation was done testing the potential of electrochemically activated anolyte and catholyte solutions to clean root canals during conventional root canal preparation, concluded that ECA solutions were better preferred over distilled water and NaOCl because they left a thinner smear layer on the surface of the tooth. NaOCl penetrated the dentinal tubules but a combination of NaOCL and ECA caused enhancement in opening of the dentinal tubules. [(26)] Even though ECA solutions have better penetration the antimicrobial effectiveness of the solution was less but significantly more than NaOCl solutions.

Ozonated water

Ozonated water is free of bacteria, viruses, parasites and chemicals. It is water that contains ozone and oxygen. It is generally used topically as healing for antibacterial and antifungal agents on burns, scrapes, bruises and surgeries in the both the dental and the medical field. Ozonated water is also known to prevent cancer. Cancer cells can multiply in the

body when there is less of oxygen. More oxygen present in the blood stream, the less cancer is able to spread. To increase the level of O2 in the body, one of the simplest ways is to drink ozonated ice cold purified or spring water. This is not only safe to drink but also enhances a healthy lifestyle. Ozonated water can be used to in periapical lesions because of its antibacterial activity and is not cytotoxic. In a comparative study of antimicrobial efficacy of ozonated water, gaseous ozone, sodium hypochlorite and chlorhexidine root canals affected by enterococcus faecalis. [27] None of these root canal irrigants were effective against microorganisms. It forms oxidized radicals in the presence of water and penetrate and acts on cell membrane. The effectiveness of the irrigant depends on the contact time, concentration, and the nature of the microorganisms. Even though ozonated water is effective against microbes, studies have proved that it is the least effective irrigant used for root canal therapy.

Alexidine

Alexidine dihydrochloride is similar to chlorhexidine but proven to have a better antibacterial action. Chlorhexidine is a widely used antimicrobial endodontic irrigant and also used as a conventional mouthwash. It is a bisbiguanide with both antimicrobial activity and substantivity. Alexidine consists of two hydrophobic ethylhexyl providing faster bactericidal activity. In comparison of the antimicrobial activity of 1% alexidine and 2% chlorhexidine irrigant on elimination of enterococc us faecalis from dentin, both agents observed eradicated approximately the same amount of bacteria. [28] Ruptured or antiseptic-attached bacteria were more frequently observed in the 10-min-soaked chlorhexidine and alexidine groups than in the 5-min-soaked chlorhexidine and alexidine groups. [28] Apart from the advantages as a root canal irrigant, this new agent is also tested and proved to be the first bibisguanide compound used for anticancer specifity.

Farnesol and xylitol

Farnesol is present in many essential oils such as citronella, neroli, cyclamen. It is used to enhance the smell of perfumes by acting as a co-solvent that regulates the volatility of the odorants. It is also used as a pesticide of insects and acts as a chemopreventive agent. **[29]** Xylitol on the other hand is one of the artificial sweeteners, with reduced or nonexistent side effects, low caloric value, and low cariogenicity compared to sucrose. Series of experiments were done to assess the antibacterial effects of farnesol and xylitol for a potential root canal irrigant. Comparison was done with sodium hypochlorite and saline. The inference obtained was that farnesol was the most effective substance in reducing the biofilm mass and the viability of the cells in the biofilm whereas xylitol only affected the biofilm mass. [30] Although not more effective than NaOCl, the combination of these two antibiofilm substances has potential to be used in endodontics in

certain situations but further studies are required.

Maleic acid

Maleic acid is an organic compound that is a dicarboxylic acid. It is a mild organic acid used as an acid conditioner in adhesive dentistry. [31] It has many industrial applications. Use of this agent was studied in comparison with ethylenediaminetetraacetic acid on the removal of the smear layer on the root canal. At the coronal and middle thirds, there was no significant difference between EDTA and maleic acid; both were equally efficient in the removal of smear layer. In the apical third, maleic acid showed significantly better smear layer removing ability than EDTA. **[32]**Maleic acid is proven to be less toxic at a comparable dose of EDTA, suggesting its potential for use as root canal irrigant. [33]

Silver diamine fluoride

Silver diamine fluoride (SDF) has been in use to arrest dental caries in many countries. Reports of available studies found no severe pulpal damage after SDF application. Infact it has been experimented to be used as an indirect pulp capping agent. **[34]** Laboratory studies have reported that S DF prevents the formation of Streptococcus mutans or Actinomyces naeslundii mono-species biofilms. **[35][36]** Arrest of active dentine caries in primary teeth by topical application of SDF solution can be enhanced by increasing the frequency of application from annually to every 6 months.**[37]** Antisepsis achieved through appropriate use of irrigants is essential for endodontic success. Identification of newer anti-bacterial agents gives alternatives to clean the canal as eradication of the infection prior to obturation does affect prognosis. Comparison of the anti-bacterial action of 3.8% silver diamine fluoride and 2% chlorhexidine gluconate against Enterococcus faecalis in root canals concluded that the use of silver diamine fluoride as an endodontic irrigant is feasible as it can effectively remove the microbes present in the canal and circumpulpal dentin. [38]

Etidronic acid and peracetic acid

Etidronic acid is a chelating agent and may be added to bind or counter the effects of metal ions. It is used to strengthen bone, treat osteoporosis, and treat Paget's disease of bone. Hard-tissue debris is accumulated during rotary instrumentation. A study investigating the use of etidronic with compatibility with sodium hypochlorite (NaOCl) concluded that hard-tissue debris cannot completely prevent hard-tissue debris accumulation during rotary root canal instrumentation. **[39]**

Peracetic acid is used mainly in the food industry, where it is applied as a cleanser and as a disinfectant. Since the early 1950’s, acetic acid was applied for bacteria and fungi removal from fruits and vegetables. It was also used for the disinfection of recycled rinsing water for foodstuffs**.** **[40]**Nowadays peracetic acid is applied for the disinfection of medical

supplies and to prevent biofilm formation in pulp industries. [41] Effects of etidronic and peracetic acid irrigation on human root dentine were all able to remove or prevent a smear layer. However, they eroded the dentin wall differently. [42] Hence, further studies need to be done to understand the overall potential use of the three agents.

CONCLUSION:

Looking at the various root canal irrigants to be used in the dental field, reformation is needed.The use of an endodontic irrigant during canal preparation is necessary to adequately debride the canal system. Even though further investigations are required for some irrigants like plant extracts; improved irrigants like maleic acid, Tetraclean and the modifications of sodium hypochlorite have proven be less toxic and compatible for the root canal. By the use of the advancements in irrigants, root canal therapy can be a great success reducing the number of microorganisms in the canal for a successful obturation. The above mentioned irrigants should be introduced to every dentist for a successful practice.

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