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Review Article

Irrigation system - a game changer in root canal treatment

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ABSTRACT:
The goal of endodontic treatment is to remove all the vital and necrotic tissues, microorganisms and microbial by-products from root canal system. This goal can be achieved through chemical and mechanical debridement of root canals. This article narrates the specifics and requirements of the irrigation solutions. Sodium hypochlorite is proposed as the primary irrigant by virtue of its organic tissue dissolution capacity and broad antimicrobial properties. On the other hand, chelation solutions are recommended as auxiliary solutions to remove the smear layer or to hinder its formation on dentin surface. Thus, it's hoped that sealers and root canal fillers can penetrate to dentin tubules and obturate the canals hermetically. There are new studies on traditional irrigants especially on some irrigants that can replace sodium hypoclorite. This article reviews the new irrigants which can be used in future endodontic practice, and their advantages and limitations. Moreover, actions and interactions of recently used irrigants are adverted.
Keywords: Irrigation solutions, chelators, sodium hypochlorite, smear layer, disinfection

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INTRODUCTION

The goal of endodontic treatment is to remove all vital and necrotic tissues, microorganisms, and microbial byproducts from the root canal system. This goal can be accomplished by chemical and mechanical cleaning of the root canal system. The anatomy of the root canal system is extremely complex and variable, and effective cleaning and disinfection are not always possible[1].

Root canals are usually shaped under constant irrigation with hand instruments and rotary systems . In a study of micro-CT images obtained before and after root canal shaping, 35% or more of the root canal surface (including the isthmus) was found to be untouched, regardless of the canal preparation technique. Therefore, the importance of irrigation and the complete disinfection of root canals has been emphasized [2]. In addition, irrigation solutions should aid removal of the smear layer. As no single solution has all of the desired properties, a combination of two or more solutions is required for safe and effective irrigation[3].

Properties of an ideal irrigant are

- Bactericidal, germicidal, and fungicidal effects
- Ability to serve as a lubricant during instrumentation
- Ability to dissolve organic dentinal tissues (pulp tissue, collagen, and biofilm) • Ability to dissolve inorganic dentinal tissues
- No irritation of periapical tissues
- Solution stability
- Prolonged and sustainable antibacterial activity after use
- Activity in an environment in which blood, serum, and tissue protein products are present
- Ability to remove the smear layer completely

- Low surface tension
- Disinfection of dentin and dentinal tubules
- No interference with periapical tissue healing
- No staining of tooth tissues
- No weakening of tooth tissues
- No triggering of a cell-mediated immune response
- No antigenic, toxic, or carcinogenic effect on the peripheral tissue cells of the tooth
- No negative effect on the physical properties of the exposed dentin
- No negative effect on the sealing abilities of sealers
- Ease of application and low cost
- Long shelf life[4]

SODIUM HYPOCHLORITE (NAOCL)

NaOCl has a broad antibacterial spectrum and is sporicidal and viricidal. Its tissue-dissolving activity is greater for necrotic tissue than for vital tissue.NaOCl reacts with organic tissue, resulting in saponification, amino acid neutralization, and chloramine reactions. Owing to its solvent effect on necrotic tissues, NaOCl has become the most widely used irrigation solution in endodontics[5].

Organic matter (inflammatory exudate, tissue residue, and microbial mass) in root canals reduces the effect of NaOCl. High concentrations of NaOCl have better tissue-dissolving effects. Low concentrations used in high volumes have potency equivalent to that of high concentrations. In addition, higher concentrations of NaOCl are more toxic than lower concentrations[6].

As the anatomy of the root canal system enables limited application to the root alone, NaOCl can be used safely and reliably in high concentrations during root canal treatment if it is not introduced into the periapical tissues. The achievement of NaOCl contact with all canal surfaces for an optimal duration is much more important than the NaOCl concentration[7].

Many mishaps, such as the splashing of NaOCl into the patient's or dentist's eye, damaging of the patient's clothes, extrusion of NaOCl beyond the apical foramen, inadvertent injection of irrigants instead of anesthesia, or allergic reaction to the irrigation solution, can occur during root canal treatment. However, NaOCl solutions are inexpensive and easy to use, and they have a long shelf life[8] .

ETHYLENEDIAMINETETRAACETIC ACID (EDTA)

Complete cleaning of the root canal system requires the combined use of organic and inorganic tissue-dissolving irrigation solutions. As NaOCl effectively dissolves only organic tissue, other solutions should be used to remove the smear layer and debris from the root canal system. The use of demineralizing agents, such as EDTA and CA, as auxiliary solutions during root canal treatment is recommended. In 1957, Nygaart-Ostby proposed the use of chelating agents to aid in the preparation of narrow and calcified root canals. The first recommended EDTA solution had a concentration of 15% and a pH of 7.3.

EDTA is used most commonly as a 17% neutralized solution. The solution reacts with the calcium ions in the dentin and forms soluble calcium chelates. Decalcification is a self-limiting process that eventually stops due to the lack of a chelator that will react quickly enough .

The ultrasonic application of 17% EDTA for 1 min is very effective for removal of the smear layer, especially from the apical third of the root, and the continuous use of liquid EDTA during root canal treatment is recommended . Under normal conditions, CHX solutions are insoluble in EDTA. The resulting precipitate is a salt formed by electrostatic neutralization of the cationic CHX by the anionic EDTA.

CITRIC ACID (CA)

CA is also available on the market and is used at concentrations ranging from 1% to 50%. The use of 10% CA as a final irrigation solution yielded very good results in terms of smear layer removal . CA has shown slightly better performance than EDTA at similar concentrations, although both solutions are highly effective in removing the smear layer from root canal walls. In vitro studies have provided insight into the cytotoxicity of chelators. A 10% CA solution was proven to be more biocompatible than a 17% EDTA solution . In one study, a 25% CA solution failed to destroy Enterococcus faecalis biofilms in 1-, 5-, and 10-min applications .

HYDROXYETHYLIDENE BISPHOSPHONATE (HEBP)

HEBP, also known as etidronic acid or etidronate, is a decalcifying agent that has little interaction with NaOCl. It has been proposed as an alternative to EDTA or CA (31). HEBP prevents bone resorption, and thus is used as a systemic drug in the treatment of osteoporosis and Paget's disease (34). However, additional studies are needed to determine whether this solution improves or shortens the duration of endodontic irrigation. Demineralization with 9% or 18% HEBP is slower than that with 17% EDTA (35).

CHLORHEXIDINE (CHX)

CHX is a powerful antiseptic used commonly for the chemical control of plaque in the oral cavity. Whereas 0.1%–0.2% aqueous solutions are used as mouthwash, a 2% concentration is used for root canal irrigation in endodontic treatment. The antimicrobial activity of CHX depends on the achievement of an optimal pH (5.5–7). CHX is bacteriostatic at lower concentrations and bactericidal at higher concentrations .

One reason for the widespread use of CHX is its prolonged antibacterial effect; CHX binds to hard tissues and maintains its antimicrobial action. This effect is due to the number of CHX molecules interacting with dentin . White et al. reported that the

effect of 2% CHX persisted for 72 h to 12 weeks . The main disadvantage of CHX is the lack of tissue solubility .

MIXTURE OF TETRACYCLINE ISOMER, ACID, AND DETERGENT (MTAD)

Torabinejad et al. introduced a combination of 3% doxycycline, 4.25% CA, and detergent (Tween-80) as an alternative to EDTA with the aim of improving smear layer removal. This mixture acts as a chelator and has antimicrobial activity. As it has no organic tissue-dissolving effect, its use after NaOCl at the end of chemomechanical preparation is recommended[9] .

MTAD is a mixture of three substances expected to affect bacteria synergistically. Its bactericidal effect on E. faecalis biofilm is less than that of NaOCl solution at concentrations of 1%–6%. The CA in the MTAD solution enables smear layer removal and allows doxycycline to enter the dentinal tubules and exert antibacterial effects . In a canal filled with AH Plus and gutta percha, the use of MTAD as a final irrigation solution significantly reduces bond strength compared with the use of EDTA . When MTAD is used instead of EDTA, resistance to tetracycline can develop in bacteria isolated from root canals[10] .

GREEN TEA POLYPHENOLS (GTP):

GTP are derived from fresh leaves of tea (Camellia sinensis), an important component of traditional Japanese and Chinese cultures. They have shown significant antibacterial activity in E. faecalis biofilms grown on dental culture, killing E. faecalis completely within 6 min .

MORINDA CITRIFOLIA (MC):

MC (noni fruit) has a wide range of therapeutic effects, such as antibacterial, antiviral, antifungal, antitumor, antihelminthic, analgesic, hypotensive, antiinflammatory, and immune-developmental effects . MC contains L-asperuloside and alizarin, which have antibacterial properties Murray et al. compared the abilities of 6% MC and 6% NaOCl irrigation solutions to remove the smear layer. As a final irrigating agent, 17% EDTA was used after both solutions[11].

ELECTROCHEMICALLY ACTIVATED WATER (SUPEROXIDIZED WATER) Electrochemically activated solutions (ECA) are produced from tap water and salt solutions with low concentrations . Anolyte solutions include combinations of oxidizing agents with microbicidal activity against bacteria, viruses, fungi, and protozoa . They are referred to as superoxidized water or oxidative potential water . They do not damage vital biological tissues and are not toxic . Electrochemical activation has produced promising results in terms of effective root canal irrigation .

OZONATED WATER

Even at a low concentration (0.01 ppm), ozone (O3) can effectively kill bacteria, including spores . It can be produced easily with an ozone generator. Ozone dissolves easily and rapidly in water . In one study, the researchers compared the microbicidal activities of ozonated water and 2.5% NaOCl under sonic activation.

CONCLUSION

Future studies of irrigants should focus on the production of a single solution that is biocompatible, has tissue-solubilizing properties, removes the smear layer, and has antibacterial effects.

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