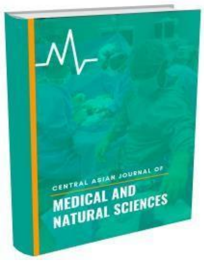

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Article

A Review: Irrigation Solutions in Endodontic Treatment

Saif Saad Kamil[1*], Aseel Taha Khaudhair[2], Ali Saad Ahmed[3], Hind Thyab Hamid[4]

1. Department of Conservative Dentistry, College of Dentistry, Tikrit University, Tikrit, Iraq
2. Department of Pedodontics, College of Dentistry, Tikrit University, Tikrit, Iraq
3. Department of Prosthodontics, College of Dentistry, Tikrit University, Tikrit, Iraq
4. Department of Preventive Dentistry, College of Dentistry, Tikrit University, Tikrit, Iraq

* Correspondence: saif1990@tu.edu.iq

Abstract: This study investigates the role of various irrigation solutions in endodontic treatment, highlighting their importance in eliminating bacteria and enhancing the success of root canal therapy. While normal saline and distilled water are commonly used due to their mild activity and ability to remove chemical remnants, sodium hypochlorite (NaOCl) is favored for its antibacterial properties and ability to dissolve tissue. Ethylenediaminetetraacetic Acid (EDTA) is typically combined with NaOCl for effective smear layer removal, while chlorhexidine is used for its ability to delay canal system recontamination. Hydrogen peroxide and MTAD, a combination of antibiotics, citric acid, and detergent, are also explored for their utility in root canal irrigation. The study aims to evaluate the effectiveness of these solutions, providing insight into optimizing endodontic treatment. Results suggest that combining specific solutions enhances bacterial elimination and overall treatment outcomes, with implications for improved clinical practices in endodontics.

Keywords: Irrigation solutions, Root canal therapy, Sodium Hypochlorite

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1. Introduction

Endodontic field examines the condition and functionality of the tooth pulp as well as the periapical tissues around the root. It focuses on the diagnosis and treatment of disorders affecting the pulp and peri radicular tissues [1]. Microorganisms present in the mouth are the most frequent reason of pulpal diseases [2]. Removing such etiological causes is the primary goal of root canal treatment. Irrigation and mechanical root canal instrumentation are thought to be crucial components in the prevention and management of periradicular illness [3].

It needs more than just mechanical instrumentation in the root canal to remove necrotic and diseased tissues [4]. Irrigation is crucial step before and during the instrumentation process [5]. The process of carrying a irrigant solution into the root canal system before to, during, and following the mechanical phase of root canal cleaning is known as irrigation in root canal treatment [6]. Irrigation procedure aims to facilitate the evacuation of germs, necrotic material, and dentin remnant from the root canal. Moreover, it can help stop the hard and soft tissues' apical extruded debris from entering the periapical region [7]. Thus, a chemical irrigant is required to kill the microorganisms, dissolving the organic tissue and flushing mechanism of debris [8].

2. Materials and Methods

Study Design

This study employed an experimental design to evaluate the effectiveness of various irrigation solutions used in root canal therapy. The study was carried out in two phases: a laboratory analysis of the chemical properties and antimicrobial effects of the irrigation solutions, followed by in vitro testing using extracted human teeth to measure their efficiency in removing bacteria, dissolving organic tissues, and eliminating smear layers.

Sample Selection

A total of 100 freshly extracted human premolars with single straight roots were collected for this study. The teeth were stored in a 0.9% saline solution at 4°C until use. These teeth were selected based on the absence of previous root canal treatments, fractures, or cracks.

Irrigation Solutions Tested

The irrigation solutions evaluated in this study were:

a. Distilled Water: Used as a baseline control for rinsing, without antibacterial properties.
b. Normal Saline: A non-toxic solution used in conjunction with other irrigants to prevent chemical reactions.
c. Sodium Hypochlorite (NaOCl): Tested at concentrations of 1%, 3%, and 5.25% to evaluate its antibacterial and tissue-dissolving properties.
d. Ethylenediaminetetraacetic Acid (EDTA): A 17% solution used to remove inorganic components and smear layers.
e. Chlorhexidine (CHX): A 2% solution tested for its antibacterial properties and residual effects.
f. Hydrogen Peroxide (H2O2): A 3% solution tested for its antimicrobial action.
g. MTAD: A solution consisting of doxycycline, citric acid, and detergent for its smear layer removal and biocompatibility.

Experimental Procedure

Root Canal Preparation: The teeth were prepared using the crown-down technique with rotary instruments. After mechanical preparation, the root canals were irrigated using 5 ml of the assigned irrigation solution. The irrigation protocol for each tooth was performed with 30-gauge side-vented needles.

1. Bacterial Elimination Test: After mechanical preparation and irrigation, each tooth was inoculated with Enterococcus faecalis to simulate bacterial infection. After incubation for 48 hours, bacterial samples were taken from the root canal system to assess the level of bacterial elimination by each irrigant.
2. Tissue Dissolution Test: Small samples of pulp tissue were immersed in 10 ml of each irrigant solution, and the time taken for complete dissolution was recorded.
3. Smear Layer Removal Test: The removal of the smear layer was assessed by scanning electron microscopy (SEM) after the irrigation phase.

Data Collection

a. Antibacterial Effectiveness: The bacterial count was measured using colony-forming unit (CFU) counts after irrigation.
b. Tissue Dissolution: The time required for pulp tissue dissolution was recorded in minutes.

c. Smear Layer Removal: SEM images were graded on a scale from 0 (no smear layer) to 3 (heavy smear layer presence).

Statistical Analysis

The data were analyzed using one-way ANOVA to compare the effectiveness of different irrigants. Post hoc tests were used to identify significant differences between groups. A p-value of <0.05 was considered statistically significant.

3. Results and Discussion

The role irrigation solutions in root canal therapy

The irrigation solution should have the best possible qualities with the fewest negative effects in order to accomplish the goals of intense cleansing and biofilm elimination from the root canal system. These roles consist of: It provided the instrument's lubricating effect during mechanical preparation [9]. It destroyed bacteria due to it has antimicrobial action against various species of bacteria [10]. The irrigant should not harming to living tissue, not irritant, and non-poisonous to apical area of human teeth [11].

Types of Irrigation solutions

Distilled water

Distilled Water does not use in endodontic disinfectant; however, it has an active effect in rinsing procedure. It has the capacity to lyse microorganisms that do not have cell walls through a hypotonic process. However, most of microorganism found in the root canals often have cell walls [12]. The most common use of distilled water is irrigant between other irrigation solution to eliminate traces of the chemical irrigant used previously [13].

To avoid a chemical reaction, it is imperative to eliminate any remaining chemical residue from the root canal [14]. A solid precipitate that occludes the dentinal tubules and creates a block between the dentin surface and the obturating substance might result from such a chemical reaction, which can cause coronal leakage. Moreover, the periapical region may be poisoned by the development of these byproducts.

Saline solution

Although saline solution has biocompatible qualities, its lack of tissue disintegration and antibacterial qualities makes it unsuitable for use as the primary irrigating solution in endodontic therapy [15]. When used as an irrigant solution between other irrigation solutions in root canal treatment, saline inhibits the development of a precipitate.

Sodium Hypochlorite

Sodium Hypochlorite often utilizes as an antiseptic agent or in bleaching procedure. Because of it has the ability to prevent the growth of bacteria and its ability to solve the organic tissue and it has lubricating properties, it is the most irrigant used in root canal therapy [16]. It is also cheap, available, and stays well protected over time if stocked adequately [17].

Hypochlorous acid, a substance found in NaOCl solution, functions as a solvent and releases chlorine when it comes into contact with organic materials. This chlorine causes a disruption in cell metabolism when it combines with an amino group found in cellular proteins to form chloramines, a process called a chloramination reaction. Hypochlorous acid (HOCl-) and hypochlorite ions (OCl-) speed up the degradation of amino acids [18]. According to (Haapasalo et al., 2014), sodium hypochlorite is the irrigating solution used in root canal treatment most frequently. Sodium hypochlorite offers a lot of benefits [19].

Sodium hypochlorite has the capacity to dissolve pulpal tissue and it has antibacterial qualities [20, 21]. Moreover, it is capable of destroying any necrotic tissues or microbiological material still present in the root canal space [22].

Unfortunately, even though NaOCl has many advantages it has some disadvantages such as: being toxic ineffective in smear layer removal and unpleasant odor [23].

There are several factors affecting NaOCl activity such as the following:

a. lowering the concentration of Sodium Hypochlorite solution decrease its toxicity, also, it decreases the antibacterial effect and the capacity to dissolve organic tissue tissues and vice versa [24].
b. Increase the volume of an irrgant lead to increase the effectiveness of irrigation solution and decrease the bacteria activity in root canal system [25].
c. The length of time that sodium hypochlorite spends in touch with the canal determines how effective it is as an antimicrobial; the longer the contact period, the more effective it is. This is crucial, particularly in situations of necrotic teeth.
d. Raising the temperature of a NaOCl solution with a low concentration will improve the irrigation solution's efficiency. It was discovered that a 1% NaOCl irrigation solution at 45°C has the same ability to dissolve organic tissue as a 5.25% NaOCl irrigation solution at 20°C. Furthermore [26].

Ethylenediaminetetraacetic Acid (EDTA)

Cleaning the canal of both organic and inorganic debris is necessary for the best possible root canal system cleaning. Since sodium hypochlorite only efficiently removes organic components, it should be used in conjunction with other irrigation solutions to dissolve additional debris and the smear layer from the root canal system [27]. During endodontic therapy, it is advised to utilize demineralizing irrigation solutions, such as EDTA, as secondar irrigation solutions. Nygaart-Ostby (1957) suggested using chelating chemicals to help prepare the narrow and calcified root canals. The concentration and pH of the first recommended EDTA irrigation solution was 15% and 7.3, respectively [28, 29].

Fraser (1974) deduced that about 0.35 μm of dentin was decalcified by 0.02 ml of ethylenediaminetetraacetic acid. In root canal therapy, EDTA is utilized to clean and sterilize the dentinal wall, reduce microleakage, and aid in the identification of canal locations [30]. At 10% and 15% concentrations on culture plates, EDTA exhibits germicidal effects in addition to its antimicrobial activity. The germicidal impact of EDTA was higher than that of citric acid and 0.5% NaOCl but less than 2.5% NaOCl and 0.2% CHX [31].

EDTA can lead to remove the minerals from the dentin, with increasing the time of the exposure and concentrations of the this irrigant the amount of dentin demineralization raises [32]. The smear layer can be actively removed by using 10 ml of 17% EDTA for one minute; however, if the exposure duration is increased to ten minutes, significant erosion of the peritubular and intratubular dentin may occur [33].

Chlorhexidine (CHX)

It was a strong alkaline substance that was used to make stable salts with excellent water solubility, such chlorhexidine digluconate [34]. The hydrophobic and lipophilic compound CHX interacts with the phospholipids and lipopolysaccharides found on bacterial cell walls [35]. Because CHX may change the osmotic balance of bacterial cells and reacts positively with the negatively charged phosphate on bacterial cell walls [36], it has beneficial effects. This may increase the cell wall's permeability and allow CHX to enter the cell [37].

In particular, Fungus, yeasts, facultative and strict anaerobes, and Gram-positive and Gram-negative bacteria that CHX is potent against [38]. CHX can be presented as a liquid or a gel for endodontic applications. Ferraz et al. (2007) found that whereas 2% CHX solution and gel had equal antibacterial qualities, the gel offered a number of benefits. The

CHX gel lubricates the root canal instrumentation process and minimizes instrument separation within the canal. The elimination of smear layer development, which does not happen with the liquid form, is another benefit of CHX gel [39].

The suggestion has been made to utilize CHX as a final irrigant in root canal therapy to capitalize on its stability, since its residual activity can extend up to twelve weeks [40,41]. Despite being useful as a latex irrigant, CHX should not be used as a primary root canal irrigant due to its inability to dissolve necrotic tissues and its lower level of activity against gram-negative bacteria [42]. Another drawback after skin contact to CHX is the potential for an allergic reaction [43].

Hydrogen Peroxide

When hydrogen peroxide is fresh, it has a pale blue tint. Diluted hydrogen peroxide is a colorless, odorless liquid that is made up of H+ and O-. It has formula H2O2 [44]. Nitric acid and barium peroxide were chemically reacted in 1818 by Louis Jacques Thénard to create hydrogen peroxide. The anthraquinone cycle, which produces H2O2 and anthraquinone when anthraquinone combines with oxygen under pressure and may then be reduced to anthrahydroquinone once again, improves it nowadays. As a non-stable oxidizing product, H2O2 interacts with metals, alkaline solutions, and oxidizable organic matter by generating free hydroxyl radicals, which then interact with DNA, lipids, and protein components to encourage their destruction [45].

H2O2 possesses germicidal qualities against a broad range of microorganisms. Under 3%, the activity of H2O2 solutions may diminish and the tolerance to H2O2 may rise [46]. The oxidation process breaks DNA strands, which is the mechanism by which H2O2 has antibacterial action [47]. However, it has a number of drawbacks, including the inability to remove organic tissue with a solvent and the recommendation that it no longer be used in dentistry due to its high toxicity [48].

Mixture of Doxycycline, Citric Acid and a Detergent (MTAD)

MTAD is a highly biocompatible substance that exhibits very little cytotoxicity and antibacterial properties. It demonstrated efficacy against E. faecalis during root canal therapy. Even when it enters the apical region, it does not disturb the apical tissues in any way. With the least amount of dentinal tubule degradation, it is the most active in elimination the root canal smear layer [49].

4. Conclusion

In conclusion, the selection of appropriate irrigation solutions plays a critical role in the success of root canal therapy, significantly impacting the removal of bacteria, necrotic tissues, and smear layers from the root canal system. Among the various irrigants examined, sodium hypochlorite demonstrated the highest efficacy due to its antimicrobial properties and capacity to dissolve organic tissues, though its toxicity and inability to remove the smear layer limit its standalone use. EDTA, chlorhexidine, and MTAD were found to effectively complement sodium hypochlorite in enhancing smear layer removal and providing extended antimicrobial action, while distilled water and saline were primarily used as intermediary solutions to neutralize chemical residues. Further research should explore the synergistic effects of combining these solutions to optimize clinical outcomes while minimizing potential cytotoxicity and tissue damage. Additionally, future investigations could focus on developing novel irrigation solutions that combine broad-spectrum antimicrobial activity with biofilm elimination, tissue dissolution, and minimal adverse effects on the periapical tissues.

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