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ELECTROLYZED SALINE... AN ALTERNATIVE TO SODIUM HYPOCHLORITE FOR ROOT CANAL IRRIGATION

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Abstract

Objectives. *The aim of this study is to evaluate electrolyzed saline, produced from a custom-made chair side apparatus for its cleaning effect on root canal walls.*

Methods. *A chair side apparatus has been designed to produce and dispense electrolytically activated solutions (Electrolyzed saline) for the purpose of root canal irrigation. Two different solutions, one, which is oxidizing in nature, consisting primarily of Chlorine derivatives and another, reducing in nature, consisting primarily of sodium hydroxide, are obtained. A combination of these two solutions was used for root canal irrigation in extracted teeth. Root canals were split and the samples were subjected to Scanning electron microscopic evaluation.*

Results. *Under the conditions of this study, electrolyzed saline significantly cleaned the root canal surfaces well, opening the dentinal tubules and removing the smear layer.*

Significance. *There has been a constant search for the ideal root canal irrigant. Sodium hypochlorite has been vastly used but its toxicity and storage risks are of concern. Electrolyzed saline has been produced from saline and the apparatus prepares and dispenses the solution chair side, obviating storage needs.*

Keywords: irrigation, electrolyzed saline

Introduction

Thorough debridement of the root canal system is essential for the successful outcome of endodontic therapy. This is achieved by mechanical instrumentation in conjunction with irrigation.

Sodium hypochlorite (NaOCl) is the most widely used irrigant [1,2,3]. It dissolves pulp tissue and is a potent anti-microbial agent. Sodium hypochlorite itself does not remove the smear layer. The combination of NaOCl and Ethylene diamine tetra acetic acid (EDTA) has been recommended for smear layer removal [4,5]. NaOCl when extruded beyond the apex causes severe pain, swelling and necrosis of the periapical tissues [6-8]. The use of concentrated NaOCl as a root canal irrigant might cause severe clinical problems when extruded into vital tissues [9]. Because of toxicity, extrusion is to be avoided [10,11], thus contraindicating its use in teeth with open apices. It is purchased and stored. Any spillage during handling causes bleaching of the clothes. Its vapor can be an irritant to the eyes. It is corrosive in nature, thus root canal instruments become more prone to mechanical breakdown.

The need remains for a treatment system that delivers an irrigation solution alternative to NaOCl having the same advantages of NaOCl but still overcoming its disadvantages of storage risks and toxicity caused when extruded through the tooth apex. The need further remains for the use of a more biologically acceptable root canal irrigant.

Russian scientists have developed a process whereby electro-chemically activated water ECA is produced with a unique anode–cathode system [12]. It utilizes a special flow through electrolyte module (FEM) consisting of cylindrical titanium electrodes separated by a ceramic membrane. A similar technology has been used by the Japanese to produce oxidative potential water (OPW). Both these solutions have been reported to be effective in smear layer removal [13-15]. The aim of this study is to prepare a

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similar irrigating solution by using a simpler technique by means of a compact indigenous chair side apparatus, which can prepare the irrigant in small quantities for immediate use. The efficacy of the produced irrigant electrolyzed saline in smear layer removal is evaluated.

The apparatus and the irrigant

The irrigating solution produced is an electrolytically activated solution prepared by electrolysis of an aqueous solution of salt. It includes an aqueous anion - containing and an aqueous cation - containing solution. The apparatus is a custom made electrolysis machine consisting of an anode and a cathode chamber with inbuilt platinum electrodes, a proton permeable membrane having pore sizes of 0.45 microns is positioned between the two chambers to allow ionic exchange during electrolysis (Figure 1). The electrolysis is performed at 10.8V DC, 500 mA current for a time period in the range of 8 – 20 minutes for 50 ml capacity chamber. The two chambers are filled with the following solutions:

1. Distilled water in the cathode compartment (room temperature).

2. 10% Sodium chloride salt solution saline in the anode compartment (room temperature).

When a circuit is established and electric current passes through water, a series of redox reactions occur on the surface of the cathode and anode. As a result of this, new elements are formed and the composition of water and the water structure is also changed [16]. In the anode compartment, NaCl and H2O will react and split into Na+, OH-, H+ and Cl-. As the membrane is proton permeable, Na+ and H+ will cross the membrane and enter into the cathode compartment. Thus, the cathode compartment contains Na+, H+ and OH-. Na+ is unstable and will form NaOH by reacting with OH- . Sodium hydroxide (NaOH) is beneficial to us as it has detergent properties. This will be useful in cleansing the root canal. This solution (solution B) will be reducing in nature and is alkaline with pH 10-11, as recorded by a pH meter.

In the anode compartment, H+ Cl-, OH- are present. Chlorine is evident in this solution by its odour. These ions may react with each other forming OCl-, HOCl- and Cl2 etc. The exact composition cannot be known but these molecules are oxidizing in nature. It will behave similar to sodium hypochlorite. The pH of this solution (solution A) is 6.5 – 7.

Electrochemical activation synthesizes alkalis in catholyte and acids in anolyte. Their concentration is proportional to water mineralization and specific consumption of electricity in the process of synthesis. The presence of alkalis in catholyte and acids in anolyte explains the difference in the pH values of the solutions collected at the anode and at the cathode.

Material and method

Sixty single-rooted human teeth were collected immediately after extraction. After conventional access preparation for each tooth, a size 15 K file MANI was used to determine the working length. The file was introduced into the canal of each root until it just reached the apical foramen. Working length was set at 1.0 mm short of that position. Canal orifices were flared with Gates Glidden burs size 2.The specimens were divided into two groups of thirty teeth each.

GROUP A: Sodium hypochlorite

The root canals of group A were prepared using a series of K-type files sizes 15–60 manually in a serial technique by circumferential filing and by irrigating with a 2.5% solution of NaOCl. Irrigation was performed after every size file. Syringe irrigation was used. After the canal was prepared to size 60, a final flush of irrigation was carried out. A minimum of 100 mL of 2.5% NaOCl was used in the irrigation process for each tooth.

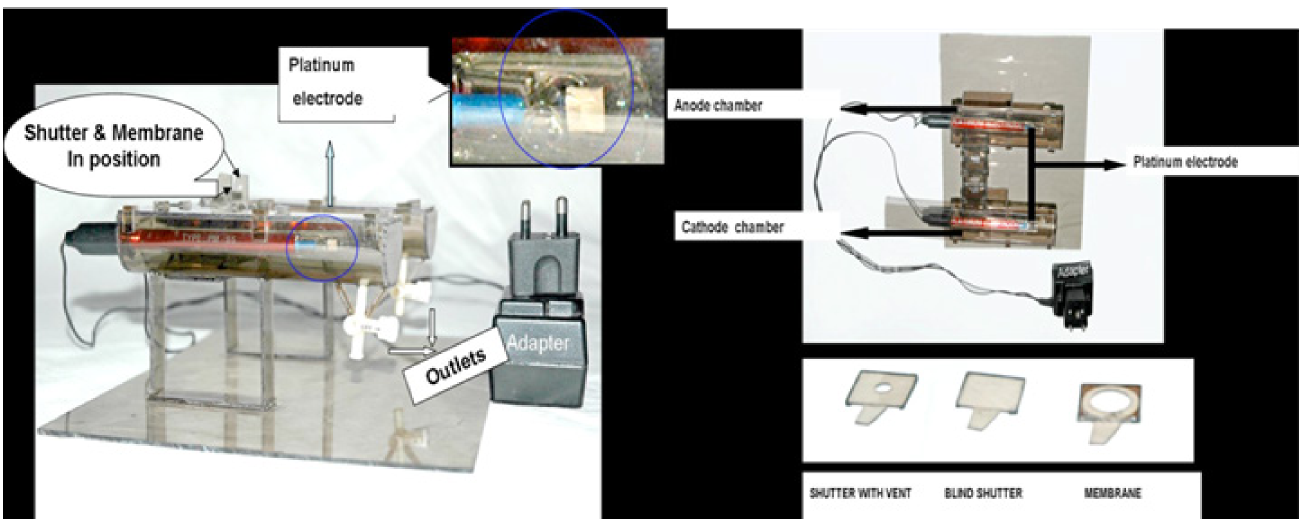

Figure 1. The apparatus.

GROUP B: Electrolyzed saline

Root canals were prepared using the same files and the same manual technique as in group A. After the use of each size file, the canal was irrigated with solution A. A minimum of 50 ml of solution A was used in the irrigation process of each tooth. Final flush of irrigation was carried out with 50 ml of solution B.

Preparation for SEM examination

The canals were not dried following preparation so as to retain the existing condition of the walls. The specimens were stored in 70% ethanol in preparation for scanning electron microscopic (SEM) examination. Longitudinal grooves were cut on the buccal and lingual surfaces with a diamond disc so as not to penetrate the canal. Each root was split in two with cutting pliers and prepared for SEM observation.

The specimens were dehydrated by graded concentrations of ethanol and freeze-dried with t-butyl alcohol. They were then mounted on aluminum stubs, coated with 20-nm gold using an Ion Sputter and stored in a desiccating cabinet to maintain dryness until SEM observation.

A scanning electron microscope operated was used to view the specimens. Photomicrographs were taken of the middle and apical thirds of all specimens at a magnification of 1000. The photomicrographs were evaluated using the rating system developed by Gorman et al. [17]) by two evaluators who were blinded to the sample group. (Score 0- No Smear layer, all tubules open; Score 1- Little smear , >50% of tubules open; Score 2- Moderate smear layer, < 50% of tubules open; Score 3 –Heavy smear layer, outline of tubule indistinguishable).

The recorded data was compiled and entered in a spreadsheet computer program (Microsoft excel 2007) and then exported to data editor page of SPSS version 15.0 (SPSS Inc., Chicago, Illinois, USA). Descriptive statistics included computation of percentages. Chi-square test (x2) was used to compare proportions for categorical data.

Results

Table I shows the comparative assessment of teeth irrigated with saline and sodium hypochlorite based on the exposure of the tubules after treatment. Eighteen of the thirty samples (60%) treated with Electrolyzed saline were free from smear layer and more than 75% tubules exposed (Figures 3, 5). Only two samples showed a heavy smear layer on the instrumented canal wall. In some sections at higher magnification X 7500, lateral and secondary tubules were evident (Figure 4). On the contrary, none of the sample showed the same score when treated with sodium hypochlorite. Most of the samples (73.3%) treated with sodium hypochlorite had tubules visible only in limited areas (Score 3) (Figure 2). The scores of Group B were significantly better in comparison to the scores of Group A.

Table I. Results of Scanning Electron Microscope Observation.

Groups	Score 1 N(%)	Score 2 N(%)	Score 3 N(%)	Score 4 N(%)	Total N (%)	p value
Sodium Hypochlorite	00	03 (10)	22 (73.3)	05 (16.7)	30 (100)	0.001*
Electrolyzed saline	18 (60)	10 (33.3)	02 (6.7)	00	30 (100)	

*p=0.001 (highly significant); Test applied: Chi square test

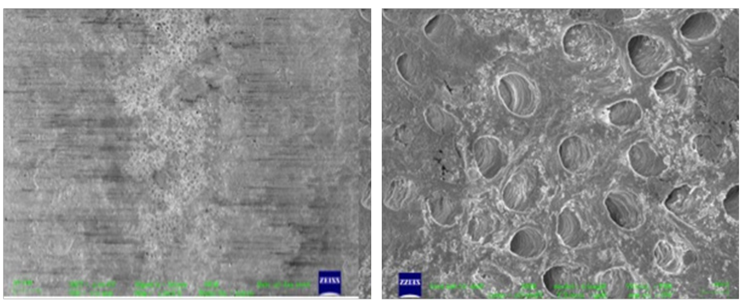

Figure 2. SEM images of samples treated with Sodium Hypochlorite (1000 X and 10,000X).

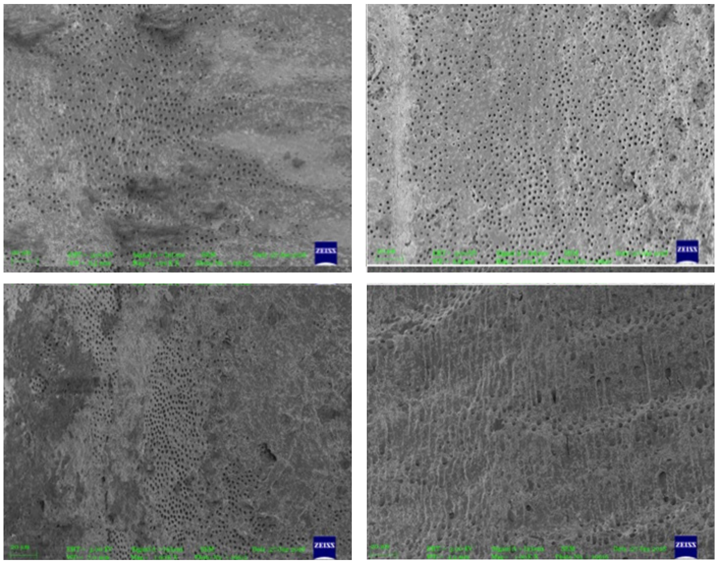

Figure 3. SEM images of samples treated with Electrolyzed saline (1000 X).

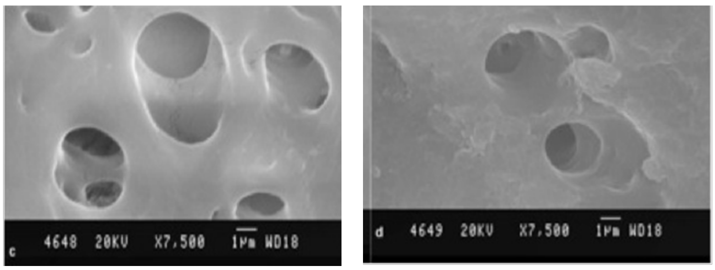

Figure 4. SEM images of samples treated with Electrolyzed saline (7500 X).

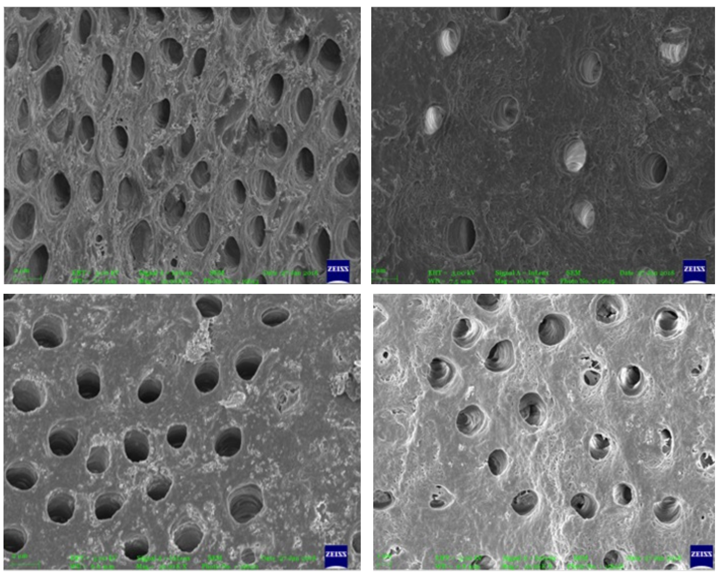

Figure 5. SEM images of samples treated with Electrolyzed saline (10,000 X).

Discussion

Long-term success of endodontic treatment depends on the thorough debridement and effective obturation of the root canal system [18]. Theoretically all the debris and bacteria should be removed from the root canal system if long-term success is to be achieved [13]. An irrigation solution that would be effective yet harmless to human tissues would be ideal. No single irrigant has been found to dissolve organic pulpal material and demineralize the inorganic calcified portion of the canal wall. The bactericidal potential of NaOCl is not in doubt [19], but the fact that it is highly toxic to human tissues is of concern

[20,21]. The solutions A and B are used alternatively in the root canal while cleaning and shaping, with a final rinse with solution B. Since these solutions contain molecules in their active form, the reaction in the canal will be immediate and effective. Moreover, even if the solutions enter the periapical tissues, the solutions mix with each other forming saline again, thus making these solutions biologically acceptable.

To remove or not to remove the smear layer has for long been a subject of controversy. Its advantages and disadvantages remain controversial. However, greater evidence supports its removal [22,23]. The organic debris present in the smear layer might constitute substrate for bacterial growth; also it may slowly disintegrate [24]. Removal of smear layer allows better adaptation of sealers to the canal wall [25]. Coronal and apical leakage is reported to be reduced after removal of smear layer [26].

Electrolyzed saline effectively cleaned the canal walls, leaving debris in only few areas. 60% of the samples showed a score 1, 33.3% showed a score 2 and only 6.7% of the samples showed a score 3. On the contrary, the samples treated with sodium hypochlorite did not show clean dentinal walls. Only 10% of the samples showed a score 2 and the rest of the samples scored 3 and 4 and showed heavy smear layer on the surface. The solution collected at the cathode (solution B) is anticipated to show cleansing action due to its detergent properties owing to the presence of Sodium hydroxide and is evident from the results of SEM examination. The use of EDTA is still recommended with rotary endodontics for lubrication. Sodium hypochlorite does not remove smear layer and the same is evident from the results of this study too, so it is combined with EDTA that acts on inorganic matter as a chelating agent and removes the smear layer.

Marais evaluated the cleaning efficacy of Electrochemically activated water (ECA) and its efficacy in root canals was found to be superior to sodium hypochlorite. ECA produced cleaner root canal surfaces than did sodium hypochlorite, and removed the smear layer in large areas [13].

The Japanese have reported, favorably, on the use of oxidative potential water (OPW) for the cleaning of root canals in teeth [14,15]. It is not clear what OPW is, but there is some reason to believe that it may be a copy of ECA being produced from similar technology [13]. It has been used extensively in Japan for household and agricultural disinfecting purposes for its safety and bactericidal effectiveness. It exerts a rapid antimicrobial effect, decomposes to plain water instantly, and is not adsorbed to dentin. It was reported that OPW used as an irrigant during and after root canal instrumentation is as effective as 5% NaOCl or 17% EDTA for opening and keeping patent the dentinal tubules [15]. In another investigation, OPW irrigation by means of syringe following instrumentation with 5% NaOCl showed a similar effect to that of 15% EDTA irrigation for removal of smear layer and debris [14].

Solovyeva and Dummer found ECA anolyte and catholyte to be effective in removing the smear layer and debris from the root canals [27]. Different authors have evaluated the antimicrobial effects of these similar groups of solutions and mixed results have been reported. Electrolyzed neutral water, produced by a proprietary electrolysis machine has been evaluated. It has shown to possess some bactericidal or growth-inhibitory effect against a selection of endodontic pathogens in vitro [28]. Electrolyzed water has been evaluated for antimicrobial effectiveness against bacteria isolated from root canals [29]. It did not effectively kill all microorganisms. Super-oxidized water produced by using the Russian technology was found to effectively kill these same bacteria [30]. In another study, the use of ECA caused a reduction in the number of anaerobic bacteria within the root canal system, but this was not statistically significant $P > 0.05$ when compared to sodium hypochlorite [31]. In a recent study, the antimicrobial efficacy of ECA was found to be comparable to sodium hypochlorite solutions [32].

Electrochemically activated water, Electrolyzed neutral water and oxidative potential water are claimed to be harmless to humans. Electrolyzed saline has been produced on the similar principle. It cleaned the root canal wall surfaces in a remarkable way, removing the smear layer in large areas. It is produced from distilled water, salt and electricity by a simple electrolytic process and a compact chair side apparatus. The fact that such clean surfaces are produced is remarkable. More research is required to determine the time and amount of the solutions best suited for clinical conditions. Its activity against pathogenic microorganisms needs to be evaluated before it is clinically introduced.

Conclusion

Under the conditions of this study, Electrolyzed saline significantly cleaned the root canal surfaces well, opening the dentinal tubules and removing the smear layer.

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