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Effectiveness of Root Canal Debris Removal Using Passive Ultrasound Irrigation with Chlorhexidine Digluconate or Sodium Hypochlorite Individually or in Combination as Irrigants

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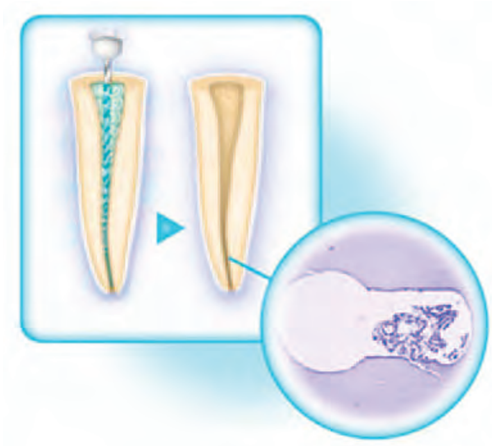

Abstract

Aim: The aim of this *in vitro* study was to evaluate the cleaning capacity of different auxiliary chemical substances energized with ultrasound in radicular dentin using morphologic analysis.

Methods and Materials: Twenty-eight single-canal, mandibular incisors were prepared with the Hero 642 canal preparation system following the sequence: 25/12, 30/06, 35/02, and 40/02, 1 mm from the apex. The specimens were then divided into four groups of seven teeth. During biomechanical preparation the teeth were irrigated with 2 ml of distilled water between files. Each group of specimens (n=7) received a final irrigation with 100 ml of the following irrigants that were activated with ultrasound for 3 minutes: Group 1- distilled water; Group 2- 0.2% chlorhexidine digluconate (CHX); Group 3- 2.5% sodium hypochlorite (NaOCl); and Group 4-the filtrate obtained after combining 0.2% CHX and 2.5% NaOCl. The apical portions of the root canals from each group were then submitted to histological processing and analyzed using optical microscopy.

Results: Results showed statistical differences between the groups ($p<0.01$). Groups 1 and 2 (distilled water and 0.2% CHX respectively) were statistically similar in terms of a greater amount of debris, whereas 2.5% NaOCl and the filtrate were more efficient in removal of debris.

Conclusion: There is no additional benefit in terms of debris removal from root canal walls by irrigating with the filtrate obtained from the combination of NaOCl and CHX when compared to using NaOCl alone.

Clinical Significance: The findings of this study suggest the time and expense of preparing and using a combination of NaOCl and CHX is not warranted compared to using NaOCl alone for root canal irrigation.

Keywords: Root canal therapy, irrigating solutions, ultra-sound, sodium hypochlorite, NaOCl, chlorhexidine digluconate, CHX

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Introduction

Historically, a variety of solutions have been suggested as root canal irrigants including inert substances such as sodium chloride (saline) or highly toxic and allergenic biocides such as formaldehyde.[1] Root canal irrigation is designed to remove pre-existing debris, dentin chips, bacteria, toxic products, and substrates necessary for bacterial growth. Sodium hypochlorite (NaOCl) at different concentrations is still the most widely accepted irrigant due to its effective antibacterial action, dissolution of organic materials, transformation of amines into chloramines as well as its deodorizing effects and ease of removal from the canal.[2,3] However, at high concentrations NaOCl is toxic and irritates periapical tissues.[4]

Currently, 0.2% chlorhexidine digluconate (CHX), at concentrations ranging from 0.1 to 2%, has been also used and shows a broad-spectrum antibacterial effect, substantivity, and low toxicity but does not dissolve organic material which is an important property for adequate root canal therapy.[5-8] The antibacterial effect of CHX is comparable to NaOCl and is effective against some resistant bacterial strains that lead to treatment failure.[9] Some authors report more favorable results with CHX for disinfecting the root canal system when compared to NaOCl.[10-11] Others, using similar methods, report better results with NaOCl.[12,13] A third group of researchers shows similar results when using either product for root canal irrigation.[14-15]

Considering the lack of agreement, Kuruvilla and Kamath[16] proposed the microbiological evaluation of the root canal system after irrigation with NaOCl and CHX alone or in combination. They found not only an increase in the antibacterial activity using a combination of NaOCl and CHX, but also tissue dissolution due to the NaOCl and lower toxicity due to the CHX. According to the authors, these effects can be attributed to the formation of chlorhexidine chlorite which increased the ionization capacity of the chlorhexidine molecule.

The constant renewal of the solution during biomechanical preparation also influences cleaning and avoids saturation, precipitation of particles, and favors the removal of debris suspended in the root canal. Irrigation can be performed with a Luer-Lok syringe, Ideal Jet pressurized syringes, or with ultrasound.[17,18]

Ultrasound is an important auxiliary for cleaning the root canal system for it provides a continuous flow of irrigating solution in the root canal to facilitate debris and smear layer removal.[19] Some authors report irrigation with ultrasound can improve results due to the mechanical agitation and temperature rise which increases the capacity of the NaOCl to dissolve organic tissue.[20,21]

Thus, this study evaluated the cleaning efficiency of the final passive irrigation using ultrasound with only a 0.2% CHX solution, then with only a 2.5% NaOCl solution, and finally with a combination of both of these solutions after biomechanical instrumentation in mesio-distally flattened root canals.

Methods and Materials

Twenty-eight single-rooted human mandibular incisors with the following characteristics were used in this study:

- Single root canal (confirmed radiographically)

- Canal length from 20 to 21 mm in length
- Completely formed roots
- Apical foramen the size of a standard diameter of a #15 file

Conventional access openings were created, and the pulp chambers were irrigated with distilled water to prevent particles entering the root canal. The working length was established with a #10 K-file (Dentsply-Maillefer, Ballaigues, Switzerland) by subtracting 1 mm from the total root length.

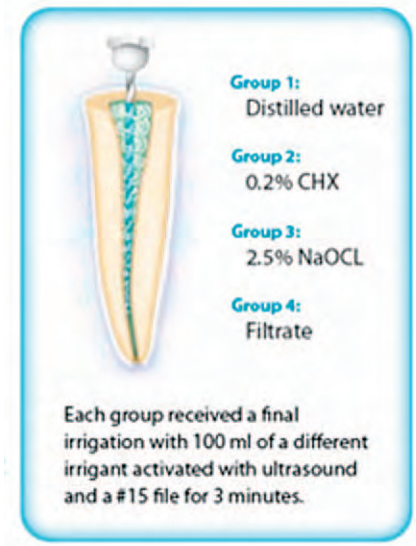
Biomechanical preparation was performed using the Hero 642 (Micro-Mega, Besançon, France) system and activated by an electric motor (Endo Plus, Driller, São Paulo, SP, Brazil) at 250 rpm. The cervical third was prepared with an Endo-Flare 25/.15 instrument, followed with a # 30/.06 instrument at the middle third, and then with #35/.02 and #40/.02 instruments at the apical third. During biomechanical preparation the teeth were irrigated with 2 ml of distilled water between files.

Kuruvilla and Kamatt16 recommend the combination of 0.2% CHX and 2.5% NaOCl solutions for root canal irrigation. Thus, in the present laboratory study a 1:1 mixture of 0.2% CHX and 2.5% NaOCl was prepared for use as an irrigant. During preparation a brownish flocculate occurred at the surface of the mixture and was removed using quantitative filter paper 12.5 cm in diameter with a 28 µm pore size (JP41; JProlab, Sao Jose do Pinhal, PR, Brazil) leaving a clear filtrate solution (Filtrate).

The 28 specimens were then divided into four groups of 7 specimens each (n=7). Each group received a final irrigation with 100 ml of a different irrigant activated with ultrasound and a #15 file for 3 minutes. The irrigants used were as follows:
- Group 1= Distilled water
- Group 2= 0.2% CHX
- Group 3 = 2.5% NaOCl
- Group 4= Filtrate

After final irrigation, all specimens were irrigated again with distilled water to remove chemical residue.

The specimens were subsequently immersed in a 10% buffered formalin for 12 hours, then washed in running water for 1 hour, decalcified in 10%



trichloroacetic acid for 15 days, and then washed again in water for 12 hours.

The apical thirds of each root were sectioned longitudinally, removed, and submitted to histological processing and then embedded in paraffin. The first millimeter of the most apical portion of the root was discarded because it was not instrumented during creation of the working length. Serial transverse cross-sections (6 μm thick) were then obtained with a microtome (Leica RM 2145, Leica Instruments GmbH, Nussloch, Germany) from the paraffin-embedded blocks. The first cross-section was selected from the remaining most apical portion of the specimens. From this point, 50 sections were discarded and the 51st slice was selected. The same procedure was followed until a total of 15 slices were selected for each specimen in order to obtain a homogeneous sample. The histological slides were stained with hematoxylin-eosin and examined with an optic microscope at 40X magnification (Eclipse E 600, Nikon, Shinagawa-ku, Tokyo, Japan) coupled to a computer in which the images were recorded with Adobe Premier 5.1 software (Adobe Systems Incorporated, San Jose, CA, USA) and analyzed with Corel Photo Paint 10 software (Corel Corporation, Ottawa, ON, Canada). A grid was placed over the images to evaluate the total area of the canal and the area containing debris. The percentage of debris in the root canal after biomechanical preparation was calculated. These data were submitted to statistical analysis using an analysis of variance (ANOVA) and the Tukey test ($p<0.01$).

Results

The percentage of debris found in the apical third of root canals is reported in Table 1.

The ANOVA was applied and showed statistically significant differences between the irrigants used ($p<0.01$). Distilled water (Figure 1) and 0.2% CHX were statistically similar, showing a high amount of debris while the 2.5% NaOCl and the filtrate were more efficient in the removal of debris.

Discussion

The use of irrigating solutions with specific chemical properties are necessary to assist instrumentation and removal of organic and inorganic residue from areas not reached by instrumentation.[5,22,23] According to Spanó et al.[2] and Cathro[5] irrigating solutions must dissolve debris; have a low toxicity; low surface tension; lubricate, sterilize, or at least disinfect root canals; and remove the smear layer.

In this study final passive irrigation was used in combination with different chemical solutions. According to Sabins et al.[17] for passive irrigation with ultrasound the file must act freely in the root canal without putting pressure on the adjacent walls and without removing dentin during this process. This passive action dislodges residue and induces liquid turbulence leading to increased hydrostatic pressure. This turbulence can lead to bubble formation due to cavitation that implodes and increases temperature and pressure, resulting in impact waves on the canal walls and removal of debris.[24] This process is helped by the continuous irrigating flux.

Table 1. Debris percentage at the apical third for each solution.

Solutions (n-7)	Mean ± SD	Statistical Difference
Group 1= H2O (distilled)	43.51 ± 1.0194	A
Group 2= 0.2% CHX	43.33 ± 2.3670	A
Group 3= 2.5% NaOCl	23.73 ± 4.4819	B
Group 4= Filtrate	24.19 ± 2.3620	B

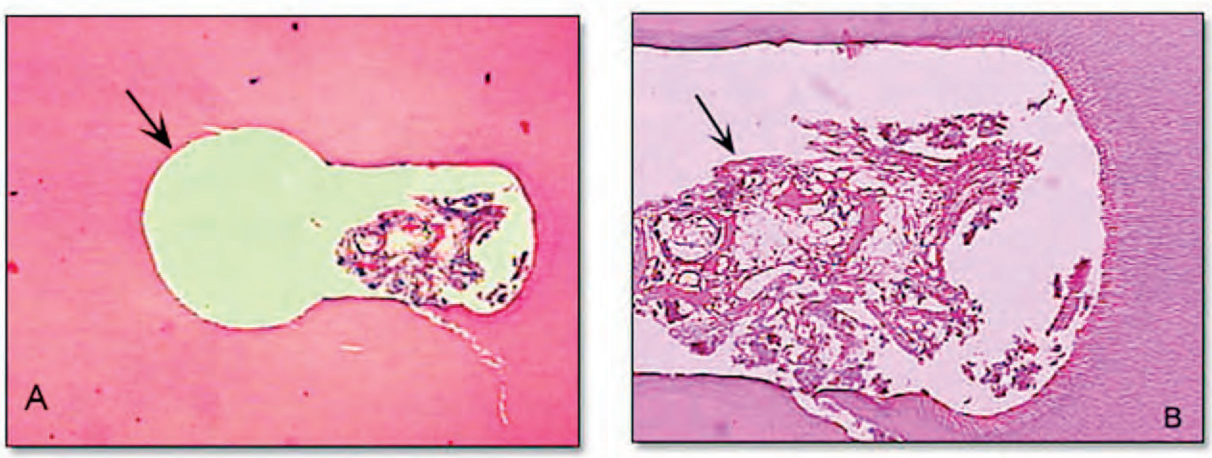


Figure 1. A. Photomicrograph of the apical region (40X magnification) showing the circular area of action of the instrument (arrow) and the area with debris in root canals irrigated with distilled water. **B.** The same image in an enlarged magnification (100X) showing the debris (*), pre-dentin and odontoblasts.

Several authors have also demonstrated ultrasound can boost the action of NaOCl[25-28] and increase CHX antibacterial activity because it increases its penetration into the dentin tubules and consequently augments substantivity.[29]

It is important to acknowledge during this study a constant volume (100 ml) of each irrigating solution associated with continuous ultrasound was used because this can influence significantly the cleaning process of the root canals.[25] Final irrigation was performed for 3 minutes because, according to Cameron[30] and Ferreira et al.,[26] the use of ultrasound for 3 and 5 minutes leads to a higher debris removal, whereas less time does not efficiently remove the smear layer.[31]

The results of the present study showed the cleaning values obtained by distilled water and 0.2% CHX were statistically similar ($p>0.01$) with the lowest cleaning results compared to NaOCl. This can be explained by the lack of tissue dissolving properties of these solutions.[32] These results agree with Naenni et al.,[33] who demonstrated increasing the concentration of chlorhexidine to toxic levels did not lead to tissue dissolution.

The results of the present study also showed cleaning achieved with the filtrate was statistically similar to that found with NaOCl ($p>0.01$) and different from water and CHX ($p<0.01$). These results can be explained by the following:

1. The increase in pH due to the removal of H+ ions (from the dissociation of HCl from NaOCl) by CHX which has a basic characteristic with negative polarity in the nitrogen element. This negative polarity attracts the dissociated hydrogen and increases the pH. This is evident when measuring the pH of the solutions: NaOCl (11.9), CHX (6.7), and the mixture of both before (13.6) and after (12.2) filtration which, according to Kuruvilla and Kamatti,[16] enhances the antibacterial action.
2. The chlorine concentration in the filtrate determined by titration was 0.8%.
3. This filtrate, as suggested by Marchesan et al.,[34] can actually be an excess of NaOCl indicating an unbalanced reaction in the quantity of moles of each solution.

Conclusion

There is no additional benefit in terms of debris removal from root canal walls by irrigating with the filtrate obtained from the combination of NaOCl and CHX when compared to using NaOCl alone.

Clinical Significance

The findings of this study suggest the time and expense of preparing and using a combination of NaOCl and CHX is not warranted when compared to using NaOCl alone for root canal irrigation.

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