Original Article

Scanning Electron Microscopic Study of the Cleaning Ability of Various Root Canal Irrigants in Primary Teeth

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Abstract

Cleaning a root canal is important for successful endodontic treatment. Currently, several irrigants have been suggested for primary teeth. The objective of this study was to evaluate the cleaning ability of various root canal irrigants in primary teeth. Forty-four primary anterior teeth with periapical lesion were selected and divided into four groups using different root canal irrigants: 1 % sodium hypochlorite; 2 % chlorhexidine liquid; 2 % chlorhexidine gel and normal saline. The roots were prepared for SEM analysis. Four areas of each one third were examined and scored. The data were analyzed using Kruskal Wallis H and Friedman test. Result showed that the best cleaning was found in the coronal third and the worst in the apical third ($P<0.01$). Cleaning result of chlorhexidine gel did not significantly differ from that of sodium hypochlorite. In addition, the cleaning ability of chlorhexidine gel was better than that of chlorhexidine liquid in all root thirds. No significant difference was observed between chlorhexidine liquid and normal saline in any root thirds. It was concluded that the least effective cleaning ability of all irrigants were found in the apical third, chlorhexidine gel showed better cleaning than chlorhexidine liquid and normal saline, but did not differ from sodium hypochlorite.

Keywords: Chlorhexidine, Irrigants, Sodium hypochlorite, Pulpectomy, Primary teeth

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Introduction

Debridement and disinfection of a root canal are considered to be essential for predictable long-term success of pulpectomy, especially in the primary teeth that have a complex root canal anatomy: accessory canals, apical ramifications, thin root canals and morphological irregularities caused by resorption.[1-4] Instrumentation and irrigation with a solution alone cannot adequately reduce infection in a root canal system. Therefore, some antimicrobial root canal irrigants, such as 1 % sodium hypochlorite and/or chlorhexidine

(CHX), are suggested to be used in primary teeth as it appears in the American Academy of Pediatric Dentistry (AAPD) guidelines.[5]

Sodium hypochlorite has been widely used in endodontics as a main irrigant because of its antimicrobial activity and ability to dissolve necrotic tissue and organic components of the smear layer.[6] However, it has a cytotoxic effect when injected in the periapical tissues, a foul smell and taste, corrosive potential, and a tendency to bleach clothes. In addition, hypersensitivity reactions have been reported.[7-9] From in vitro observations, it appeared that a 1 % sodium hypochlorite has a less irritating effect to the tissue compared to one with a higher concentration.[10-18] With more contact time and frequent exchange of irrigant, 1 % sodium hypochlorite can produce sufficient results in dissolving the entire pulp tissue and yield antimicrobial effectiveness. The in vivo study also found that irrigation with 1 % sodium hypochlorite resulted in a significant difference in decreasing the microbial load.[19]

Chlorhexidine has been recommended as a root canal irrigant because of its broad spectrum antimicrobial action, low grade of toxicity[20], and substantivity effects.[21-24] Chlorhexidine at 2 %, in liquid form is usually found in endodontics literature as a root canal irrigant whereas gel form has been suggested as an intracanal medication. An *in vitro* assessment of the mechanical ability of CHX gel as an endodontic irrigant in permanent teeth demonstrated good performance.[25]

From previous in vitro studies, both 1 % sodium hypochlorite and 2 % chlorhexidine exhibited a potential to kill bacteria. Although chlorhexidine has less ability of disrupting the biofilms than sodium hypochlorite,[6,26,27] it exhibits substantive effects that may prevent root canal infection.[6,28,29] Furthermore, chlorhexidine was found to have less toxicity than sodium hypochlorite.[30,31] In contrast, the lack of tissue dissolving ability of this material, is one of the important benefits of sodium hypochlorite.[6] Therefore, other properties such as cleaning ability are also important and should not be dismissed when one is weighing the pros and cons of a substance to be used as an irrigant in endodontic procedures.

Previous studies have compared the ability in cleaning root canal walls of chlorhexidine to sodium hypochlorite in permanent teeth.[25,32] Only a few studies have demonstrated the effectiveness of irrigants in primary teeth.[33,34] Currently, no comparison studies on the root canal wall cleaning ability between 1 % sodium hypochlorite and 2 % chlorhexidine have been carried out. Therefore, the aim of this study was to evaluate the cleaning ability of 1 % sodium hypochlorite and 2 % chlorhexidine in liquid and gel form as an endodontic irrigant for primary teeth.

Materials and Methods

The experiment was approved by the Ethics Committee of Mahidol University (MU-DT/PY-IRB 2014/DT045).

A total of 44 primary anterior teeth with a single straight root were extracted due to an unrestorable crown and periapical lesion, and then stored in normal saline. The crowns were sectioned with a D8 diamond bur at the cemento-enamel junction. Samples were excluded if they had excessive curvature, canal obstruction, internal root resorption, a root length of less than 10 mm or the diameter of the root canal was less than a size 25 K-file. Each root then had its apex covered with sticky wax. Mechanical preparation was performed by only one operator using three K-files with circular filing motion for 60 seconds each time. Instrumentation was initiated with the file best fitted to the root canal, followed by two other larger files. Before using another file, the canal was irrigated with 1 ml irrigant and a final flush was performed with 3 ml of the same irrigant as follows: group 1, 1 % sodium hypochlorite; group 2, 2 % chlorhexidine liquid; and group 4, normal saline.

In group 3, all specimens were coated with 2 % chlorhexidine gel using K-file before mechanical

preparation. The canal was then irrigated with 1 ml of saline before using another file and a final flush was performed with 3 ml of normal saline.

The root canals were dried with paper points. The samples were fixed in 2.5 % glutaraldehyde and 2 % paraformaldehyde for 12 hours at 4°C. The roots were then longitudinally split in the bucco-lingual direction followed by dehydrating to the critical point and covered with a 20-nm layer of gold for analysis with a scanning electron microscope at magnification 1000X. Four areas of coronal, middle, and apical thirds of each root were evaluated for the cleaning by Yamashita *et al* scoring 32 ranged from 0-3 as shown in Fig.1.

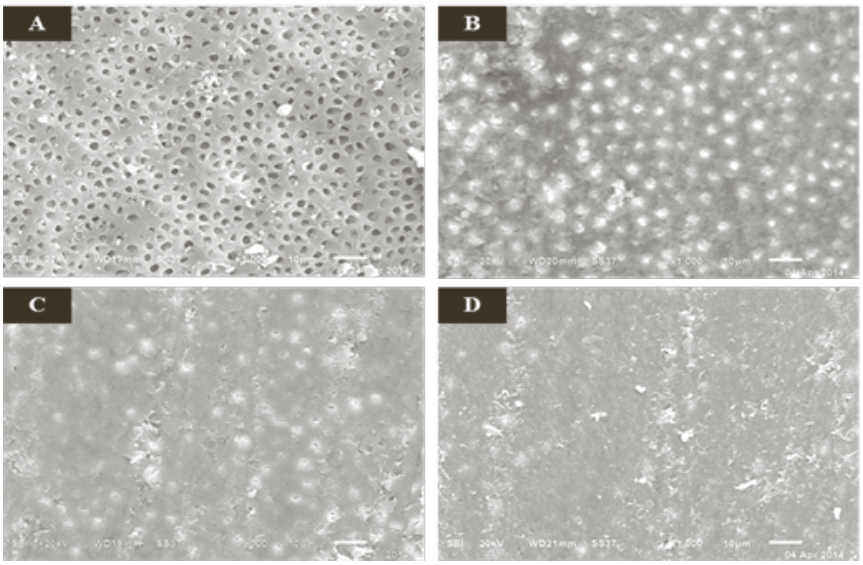

Figure 1 *Scanning electron micrographs of scores 0-3 (A-D) used to evaluate cleaning capacity of the irrigants.*
A : score = 0 (surface free of debris and residue with openings of total dentinal tubules)
B : score = 1 (almost all visible dentinal tubules with a thin covering of residue on the opening)
C : score = 2 (thin covering of residue on the dentinal tubules with visible tubules only in a few regions)
D : score = 3 (surface totally covered with debris with no visible dentinal tubule openings)

The photomicrographs were taken by only one investigator who was blinded to irrigant groups. The score of cleaning ability in each photograph was interpreted by a different researcher who was assessed for the degree of intra-examiner reliability.

The data were statistically analyzed using the Kruskal Wallis H test and the Mann Whitney test to compare the results among the four groups. Cleaning scores among 3 root thirds in each treatment group were compared by the Friedman test. For all tests performed, a two-tailed $P<0.05$ was considered as statistically significant.

Results

The intra-observer reliability of the evaluation method using the Weighted KAPPA values indicated excellent observer agreement (Weighted KAPPA values 0.896-0.947).

Comparing the cleaning ability of irrigants among 3 root thirds, the most effective results were found at the coronal third followed by the middle and apical third respectively. The statistical differences of all treatment groups were observed between the coronal and apical third of the root.

The results showed no difference in the cleaning ability between chlorhexidine gel and sodium hypochlorite in the coronal and apical thirds of roots. However, significant differences were observed among the chlorhexidine gel group, chlorhexidine liquid, and normal saline group in the apical third of the root (P<0.001). The cleaning scores of chlorhexidine gel significantly differed from that of chlorhexidine liquid in all root thirds. No significant difference was observed between the chlorhexidine liquid group and the normal saline group in any root thirds. Dispersion of cleaning ability scores of each irrigant in three root thirds are presented in Figure 2. SEM images of coronal, middle, and apical thirds in each group are shown in Figure 3.

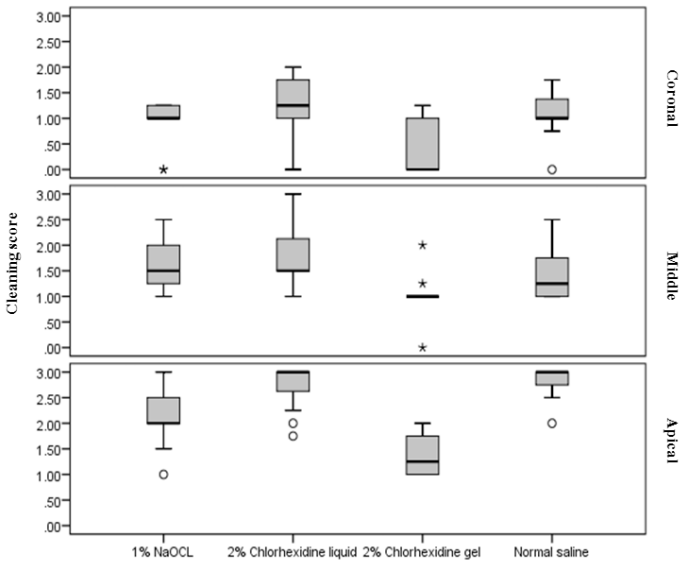

Figure 2 *Dispersion of cleaning capacity scores of each irrigant in 3 root thirds.*
○ represents the mild outlier (the data does not exceed three times from the 25th or 75th percentile).
** represents the extreme outlier (the data exceeds three times from the 25th or 75th percentile).*

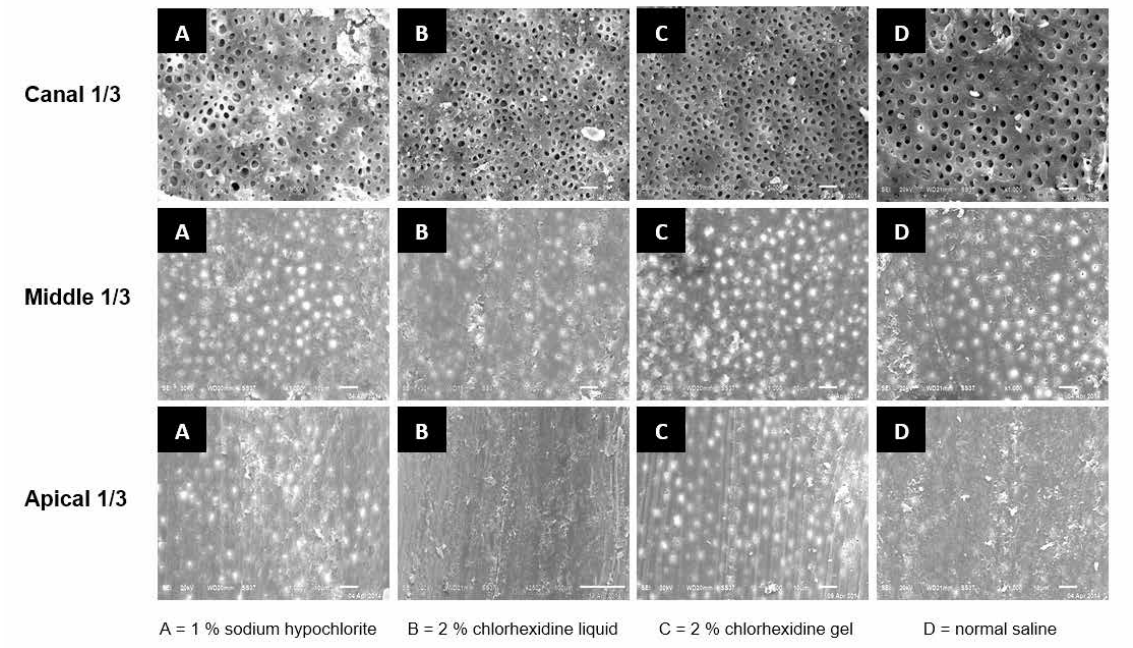

Figure 3 *SEM images (magnifications of 1000x) of root canal at coronal, middle, and apical thirds in each irrigant.*

Discussion

Cleansing of the root canals makes dentinal tubules more permeable. The irrigant flushes out the remaining microorganisms and debris. Moreover, it removes the smear layer, permitting greater penetration of intracanal medicaments in dentinal tubules as well as improving the adaptation of root canal filling materials.[6]

Several irrigants have been suggested for more effective results during the chemical-mechanical preparation not only as antimicrobial agents, but also to increase the efficiency of root canal instrumentation, remove the smear layer, and flush away debris. In addition, irrigants used among young children should have low toxicity to avoid any harm from uncooperative behavior or extrusion of the irrigant beyond the apex due to resorption of the primary root.

Laboratory study is the first step to evaluate the efficacy of irrigants. The SEM analysis is the most popular tool to identify debris and smear layer on the root canal wall after root canal preparation. In this present study, root canals of the primary anterior teeth with pulp necrosis were used to investigate the cleaning ability of various irrigants. This study used a score scale according to Yamashita *et al.*[32] because it was clear and easy to understand, which was confirmed by high weighted KAPPA values.

For overall cleaning ability of irrigants in this study, no significant difference was found between chlorhexidine gel and sodium hypochlorite, demonstrating good performance. Chlorhexidine (CHX) in gel form presented better cleaning results than chlorhexidine in liquid form. In addition, the chlorhexidine solution showed no significant difference in cleaning efficiency compared with normal saline confirmed by Yamashita *et al.*[32] The different results of CHX gel and liquid corresponded to the study of Ferraz *et al.*[25] However, they reported almost all tubules opened in the 2 % chlorhexidine gel group whereas this investigation showed some residue at the opening of the dentinal tubules. Possible reasons are differences in specimen preparation and the investigated area. The previous study used ultrasonic bath specimens and analyzed only the middle third of the root canal.[25] The investigation showed that the worst cleaning results of all irrigants were observed in the apical third of the root corresponding to the study of Ximenes *et al.*[34] This may relate to the smaller diameters of root canal when compared with coronal and middle ones. The circulation action of irrigants may have been restricted from smaller diameters of the apical third, producing less efficiency in removing the smear layer.

In the apical third of root, the CHX gel showed better cleaning results than the chlorhexidine liquid and normal saline, but showed no significant difference in cleaning ability from sodium hypochlorite. The ability to dissolve necrotic tissue and organic components of sodium hypochlorite and the mechanical properties of chlorhexidine gel might be the factors producing effective cleanliness. The consistency of CHX gel, which the instrument can carry it throughout the root canal especially in the apical root third and facilitating cleaning action (lubricant action during instrumentation) and removing smear layer and tissue by normal saline flush that may compensate for the inability to dissolve pulp tissue of chlorhexidine. On the other hand, the CHX liquid have only flushing action like normal saline. Therefore, the cleaning ability of the CHX liquid depends on cleanliness of the instrumentation action and depth of irrigant flushing throughout the canal. However, this study used only irrigating solutions without chelating agents such as EDTA or citric acid that is extensively used in permanent teeth to remove inorganic portions of the smear layer. Thus, inorganic residues may not be removed from root specimens. Finally, the effectiveness of adjuvants in primary teeth was not shown significantly both *in vivo* and *in vitro* study.[33,34]

From previous studies regarding antimicrobial

activity and safety effect of irrigants,[5,6,20,21,23,24,30,31] chlorhexidine has been accepted for these properties as an irrigant for pulpectomy especially in primary teeth. In addition, the cleaning ability results of this study indicated that gel form may compensate for the inability of chlorhexidine to dissolve organic tissues by mechanical action. As a result, chlorhexidine gel is an appropriate option as an endodontic irrigant in primary teeth. However, further clinical studies on chlorhexidine gel use as an endodontic irrigant should be undertaken.

Conclusion

Based on the results of this study, the following conclusions can be made:

1. The least effective cleaning ability of all irrigants was found at the apical third of the root.

2. There were no statistically significant differences in the cleaning ability between chlorhexidine gel and sodium hypochlorite in the apical third of the root.

3. The gel form of chlorhexidine presented better cleaning results than chlorhexidine in liquid form.

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