Six percent citric acid better than hydrogen peroxide in removing smear layer: an in vitro pilot study

Fouad S. Salama, BDS, MS Faika Y. Abdelmegid, BDS, MS

Introduction

The smear layer in endodontically instrumented root canals first reported in 1975[1] is both organic and inorganic in composition.[2] The inorganic material in the smear layer is composed of tooth structure and some nonspecific inorganic contaminants.[2] The organic components may consist of heated coagulated proteins, necrotic or viable pulp tissue, and odontoblastic processes plus saliva, blood cells, and microorganisms.[2]

Different irrigation solutions have been used to remove the smear layer. Sodium hypochlorite, in 1.0 to 5.25% concentrations has not been shown to effectively remove the smear layer but will dissolve organic tissue.[3] Physiological saline solution[3] and hydrogen peroxide[4] do not have any effect on removing dentinal debris and the smear layer. Sodium hypochlorite irrigation followed by hydrogen peroxide did not give good results.[3] Polyacrylic acid in 5, 10, and 20% concentrations removed the smear layer and the dentinal tubules were patent, with much scattered debris.[1,5] Different concentrations of citric acid[6] and EDTA[7] have moderately or completely removed the smear layer. Lactic acid,[6] Tego® (Goldschmidt Products Corp, White Plains, NY),[8] Gly-oxide® (MARION Labs, Kansas City, MO), and Salvizol® (Ravensberg GMbH, Konstanz, FRG, Germany),[9] and tannic acid[10] have not removed the smear layer satisfactorily. These various cleansing and irrigation agents' effect on primary teeth have not been reported. The purpose of this study was to test the effectiveness of four irrigating solutions, used singly, to remove the smear layer of the primary incisor root canals as observed through the scanning electron microscope (SEM).

Methods and materials

Twenty-four extracted primary incisors with at least two-thirds of the root intact were obtained from several dental practices and preserved in 10% formalin. Teeth had been extracted for a variety of reasons including abscess formation, pulpitis, trauma, and orthodontic considerations. Tooth preparation was performed using a modification of the technique described by Aktener and Bilkay.[7] An access cavity was prepared with a No. 4 round bur in a high-speed handpiece and a No. 10 K-type file inserted into each canal until it was visible at the apical end; 2 mm were subtracted from this length in order to establish the working length.

The apical end of each canal was sealed with casting wax and two parallel longitudinal grooves, which did not penetrate the root canals, were made on the external surface to facilitate fracture of the teeth. The teeth were instrumented sequentially using K-type files to size 50. Irrigation was accomplished after each file size, using 1 ml of physiological saline. All irrigations were carried out with a 25-gauge needle attached to a 10-ml syringe, which was placed at two-thirds of the working length in each canal. The final irrigation was performed using 5 ml of the tested irrigant followed by 10 ml of physiological saline.

The teeth were divided into six groups with four teeth in each group. The teeth in the test groups were irrigated with 5.25% sodium hypochlorite for 15 sec(Group 1) and 30 sec (Group 2), 6% citric acid for 15 sec (Group 3), and 30 sec (Group 4), and 3% hydrogen peroxide for 30 sec (Group 5). The teeth in the control group were irrigated with physiological saline for 30 sec (Group 6).

Canals were dried with paper points at the end of the test process. The casting wax was removed and the teeth were split in half and prepared for the SEM (Jeol JSM - T 330 A).

The coronal and middle thirds of the canals were scanned to determine the amount of soft tissue and hard tissue debris, as well as to ascertain the presence or absence of the smear layer. Representative photomicrographs were recorded and evaluated by one examiner without knowledge of the experimental groups, according to a modification of the rating system developed by Rome et al.[9]: 0 = no smear layer, dentinal tubules open and free or partially filled with debris (Fig 1); 1 = moderate smear layer, outlines of dentinal tubules visible or partially filled with debris (Fig 2); and 2 = heavy smear layer, outlines of dentinal tubules obliterated (Fig 3). The data were analyzed using the Kruskal-Wallis nonparametric ANOVA and nonparametric Tukey's multiple range tests. [11]

Results

The Table shows the scores for smear layer and the number of samples at different levels using Rome et

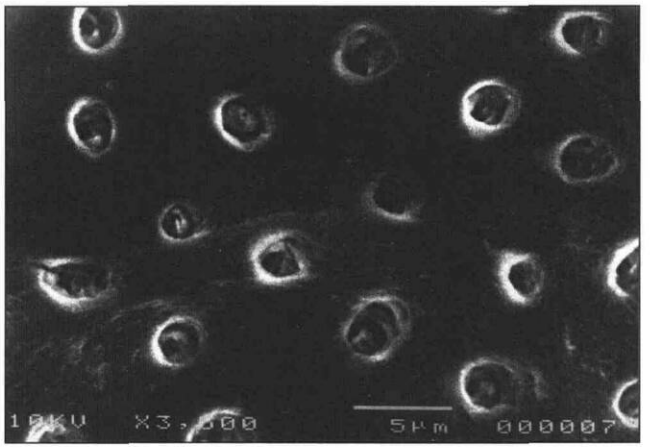

Fig 1. Score 0 — No smear layer, dentinal tubules open and free or partially filled with debris.

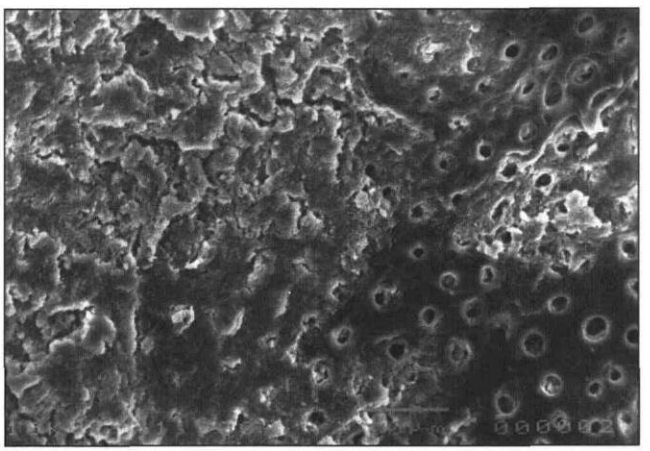

Fig 2. Score 1 — Moderate smear layer, outlines of dentinal tubules visible or partially filled with debris.

al.'s classification. In Group 1, a moderate smear layer was present at the coronal and middle thirds and the outlines of the dentinal tubules were visible or partially filled with debris in all samples (score 1) except in the coronal third of one specimen, which showed no smear layer (score 0). In Group 2, the smear layer was removed from the coronal and middle thirds and the dentinal tubules were open, but partially filled with debris in all samples (score 0) except in the middle third of one specimen, which showed moderate smear layer (score 1). In group 3, the smear layer was removed completely from the coronal and middle thirds in all samples and the openings of the dentinal tubules were patent (score 0). In Group 4, the smear layer was removed completely from the coronal and middle thirds in all samples and the openings of the dentinal tubules were patent (score 0) as in Group 3. In Group 5, four samples (two coronal and two middle) showed moderate smear layer (score 1) and four samples (two coronal and two middle) showed heavy smear layer (score 2) in the coronal and middle thirds. In Group 6, a heavy smear layer was present at the coronal and middle thirds in all samples (score 2).

Table. Scores for the smear layer at different levels and number of samples (thirds) using Rome et al. classification

Group	*0*	*1*	*2*
1	1	7	none
2	7	1	none
3	8	none	none
4	8	none	none
5	none	4	4
6	none	none	8

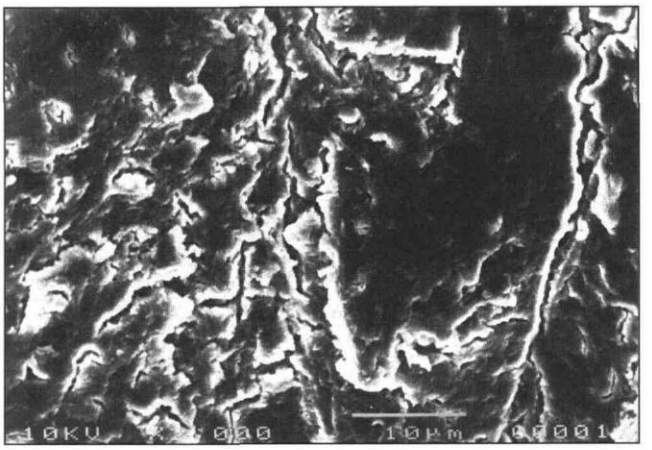

Fig 3. Score 2 — Heavy smear layer, outlines of dentinal tubules obliterated.

The coronal and middle thirds of each group were compared. ANOVA showed that there was a statistically significant difference between the groups when the coronal thirds were compared ($P = 0.000893$). Multiple range test showed that there was a significant difference between Group 6 and Groups 2, 3 and 4. ANOVA showed that there was a statistically significant difference between the groups when the middle thirds were compared ($P = 0.000956$). Multiple range test showed that there was a significant difference between Group 6 and Groups 3 and 4.

Discussion

One examiner rated the effects of the various cleansing agents. Intraexaminer reliability was not performed. However, after evaluation of the samples under SEM, a modification of Rome et al.'s classification was made before rating. This modification added dentinal tubules partially filled with debris to score 0, which included absence of smear layer and open, free dentinal tubules to facilitate repeated evaluation and scoring. In the present study, formalin fixation of the teeth was used. A possible disadvantage of this fixative on mechanical cleaning may be the hardening of the organic material in the root canals.

The morphology of the root canals of primary teeth[12] as well as the microbiology of the infected teeth[13] are significant barriers to adequate cleaning. Since many of the root canal ramifications cannot be reached

mechanically, copious irrigation is important during cleaning and shaping. Prior studies have found that instrumentation alone cannot clean the canal thoroughly[14] or remove the smear layer.[2, 10] In this study, a heavy smear layer was observed at all levels in the specimens irrigated with saline solution, consistent with previously published reports on permanent teeth, which found that saline alone produces a sludge layer made up of residual debris that occluded the dentinal tubules.[7, 8, 10] After 15- and 30-sec application, 6% citric acid totally removed the smear layer and opened the dentinal tubules. This finding is consistent with a previously published study on permanent teeth that reported a 6% citric acid solution applied for 60-sec removed the smear layer and smear plugs in the tubules.[6]

It is interesting that 6% citric acid is quite effective in the primary teeth in as short a time as 15 sec. It is not known how deep the acid can penetrate the dentinal tubules or if the buffering capacity of the dentinal fluid in vivo is adequate to neutralize the applied acid. Therefore, caution should be taken because of possible toxic effects of citric acid on the periapical or furcation areas. In this study, a 5.25% sodium hypochlorite applied for 30-sec removed the smear layer while a 15-sec application left a moderate smear layer. This is in contrast to the inability of sodium hypochlorite to remove the smear layer by itself in permanent teeth.[2, 8] This difference between the primary and permanent teeth may be due to differences in composition of the smear layer or differences in the sodium hypochlorite properties.

It has been shown that certain properties of sodium hypochlorite can be altered by thermal, physical, chemical, and other means.[15] Sodium hypochlorite, in a 5.25% concentration has antimicrobial activity, is an effective solvent of necrotic tissue, helps debride the canal system, and is nontoxic to the periapical tissues.[15] Citric acid, in addition to removing the smear layer, is a powerful antimicrobial agent, but not as great as that of 5.25% sodium hypochlorite. Hydrogen peroxide was ineffective in removing the smear layer. This is consistent with other studies with reported ineffective removal of the smear layer in permanent teeth, even after extended exposure.[2, 16] The difference between in vitro and in vivo studies may be that in the clinical situation the irrigating solutions have very limited surface contact and also may be quickly buffered (neutralized).[17]

As indicated by this study, a single solution may be used to remove all the components of the smear layer. Absence of the smear layer in citric acid groups indicates that it probably contains significant amounts of calcified tissue. In the same vein, the absence of the smear layer after 30-sec application of sodium hypochlorite, may indicate that it has organic components. Further research is needed to investigate the biocompatibility of citric acid and to test combinations of solutions. The results of this study indicate that irrigation with 6% citric acid for 15 or 30 sec is quite effective in removing all the components of the smear layer of the primary incisor root canals.

The authors thank Dr. Nazeer Khan Biostatistician, Research Center, College of Dentistry, King Saud University for statistical management of the data and Professor Joseph Adenubi for reviewing the manuscript. This study was supported by the College of Dentistry Research Center, King Saud University, Grant # F 1056.

Dr. Salama is assistant professor, division of pedodontics; Dr. Abdelmegid is assistant professor, division of oral biology and pathology, both at the College of Dentistry, King Saud University.

1. McComb D, Smith DC: A preliminary scanning electron microscopic study of root canals after endodontic procedures. J Endod 1:238–42, 1975.
2. Czonstkowsky M, Wilson EG, Holstein FA: The smear layer in endodontics. Dent Clin North Am 34:13–25, 1990.
3. Baumgarmer JC, Mader CL: A scanning electron microscopic evaluation of four root canal irrigation regimens. J Endod 13:147–57, 1987.
4. Meryon SD, Tobias RS, Jakernan KJ: Smear removal agents — a quantitative study in vivo and in vitro. J Prosthet Dent 57:174–79, 1987.
5. McComb D, Smith DC, Beagrie GS: The results of in vivo endodontic chemomechanical instrumentation — a scanning electron microscopic study. J Br Endod Soc 9:11–18, 1976.
6. Wayman BE, Kopp WM, Pinero GJ, Lazzari EP: Citric and lactic acids as root canal irrigants in vitro. J Endod 5:258–65, 1979.
7. Aktener BO, Bilkay U: Smear layer removal with different concentrations of EDTA ethylenediamine mixtures. J Endod 19:228–31, 1993.
8. Goldman LB, Goldman M, Kromman JH, Lin PS: The efficacy of several irrigating solutions for endodontics — a scanning electron microscopic study. Oral Surg Oral Med Oral Pathol 52:197–204, 1981.
9. Rome WJ, Doran JE, Walker WA: III — The effectiveness of Gly-Oxide and sodium hypochlorite in preventing smear layer formation. J Endod 11:281–88, 1985.
10. Bitter NC: A 25% tannic acid solution as a root canal irrigant cleanser — a scanning electron microscopic study. Oral Surg Oral Med Oral Pathol 67:333–37, 1989.
11. Zar JH: Biostatistical Analysis, 2nd Ed. Englewood Cliffs, NJ: Prentice-Hall International, Inc, 1984.
12. Salama FS, Anderson RW, McKnight-Hanes C, Barenei JT, Myers DR: Anatomy of primary incisor and molar root canals. Pediatr Dent 14:117–18, 1992.
13. Marsh S J, Largent MD: A bacteriological study of the pulp canals of infected primary molars. ASDC J Dent Child 34:460–70, 1967.
14. Mizrahi S J, Tucker JW, Seltzer S: A scanning electron microscopic study of the efficacy of various endodontic instruments. J Endod 1:324–33, 1975.
15. Harrison JW: Irrigation of the root canal system. Dent Clin North Am 28:797–808, 1984.
16. Titley K, Torneck CD, Smith D: The effect of concentrated hydrogen peroxide solution on the surface morphology of cut human dentin. J Dent Res 67 Sepc Iss, Abstr No 1307:276, 1988.
17. Walton RE, Toralinejad M: Principles and Practice of Endodontics. Philadelphia: WB Saunders Co, 1989, pp 205–6.