ORIGINAL RESEARCH

Evaluation of ethylenediaminetetraacetic acid (EDTA) solution and gel for smear layer removal*

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Abstract

The purpose of this *in vitro* study was to compare the efficacy of 24% ethylenediaminetetraacetic acid (EDTA) gel and 17% EDTA solution in cleaning dentine walls after root canal instrumentation. Thirty human canine teeth were divided into three groups of 10 teeth each. In Group 1, 1% sodium hypochlorite was used as the irrigating solution; in Group 2, 1% sodium hypochlorite was used with 17% EDTA solution; and in Group 3, 1% sodium hypochlorite was used with 24% EDTA gel. The presence of a smear layer was analysed after instrumentation using scanning electron microscopy. The Kruskal–Wallis test revealed a statistical difference ($P < 0.05$) between Groups 1 and 2, and also between Groups 1 and 3. No difference was observed between Groups 2 and 3 ($P > 0.05$). The results indicate that 1% sodium hypochlorite alone does not remove the smear layer and that there was no statistical difference between EDTA gel and EDTA solution in smear layer removal.

Introduction

The action of endodontic instruments on dentine walls leads to the formation of a smear layer comprising inorganic and organic matter. Elimination of the smear layer results in smoother walls and in dentinal tubules of circular shape and slightly amplified diameter. As a consequence, the root canal wall comes into closer contact with the filling material, which may penetrate the dentinal tubules, increasing adhesion and sealing capacity (1–3).

All canal preparation techniques cause the formation of a smear layer that reduces dentine permeability. However, the literature is not clear concerning the clinical relevance of this (4). The general rule seems to be to remove the smear layer, making for easier diffusion of intracanal medication on dentine walls (5).

According to Braguetto *et al.*, the cleaning action of ethylenediaminetetraacetic acid (EDTA) in association with sodium hypochlorite solution results in cleaner canals, with a lower percentage of debris than that obtained using other solutions (6).

Currently, the chelating agent EDTA is extensively used to remove the smear layer formed during the chemomechanical preparation of the root canal. However, there are few studies comparing the action of this chelating agent in its liquid and gel forms.

The aim of this study was to evaluate, *in vitro*, the ability of a 17% EDTA solution and 24% EDTA gel to remove debris and smear layer produced during root canal preparation.

Materials and methods

This study was approved by the Research Ethics Committee at the Centro de Pesquisas Odontológicas São Leopoldo Mandic, Campinas, Brazil.

Thirty human canine teeth, with completely formed apices, were selected from the human tooth bank at the Denta School, Universidade Camilo Castelo Branco. All had a single root and were extracted for various reasons. The crowns were sectioned at the cemento-enamel junction. After discarding the crowns, the roots were immersed in physiological saline solution for 72 h for hydration.

To prepare the root canals, the samples were held in a vice fixed to a lathe bed. The initial instrumentation of the canal was performed with a 10-K file (with 2 mL of 1% sodium hypochlorite solution) to the apical foramen.

All the canals were instrumented with K-type files up to size 50. Canal preparation was performed sequentially with irrigation and only brand new Flexofile (Dentsply-Maillefer) K-files were used. The working length was set 1 mm short of the apical foramen.

The irrigating agents were introduced from a disposable 5 mL syringe with a 25 blunt hypodermic needle that was inserted 3 mm from the apical foramen.

Aspiration and irrigation were performed sequentially. A 40:20 aspiration cannula was fitted into the root canal. EDTA 24% gel was used in accordance with the manufacturer's instructions – the amount used was sufficient to fill the canal entrance. After that, a file was used to introduce the gel into the canal during instrumentation. After the chemomechanical preparation, all the teeth were irrigated with distilled water. The canals were then aspirated and left to dry in their respective uncovered bottles. The teeth were divided into three groups, as follows:

Group 1: In this group, 1% sodium hypochlorite was used during canal preparation. Two millilitres of solution was used to irrigate the canal after each instrument.

Group 2: In this group, 2 mL of 1% sodium hypochlorite was used with first instrument, then 2 mL of 17% EDTA solution and 2 mL of 1% sodium hypochlorite were used alternately each time a new size of file was employed, until instrumentation was completed.

Group 3: In this group, 24% EDTA gel was introduced in the canal with the first instrument. After that, 2 mL of 1% sodium hypochlorite and 2 mL of 24% EDTA gel were used alternately after each instrument until the end of instrumentation.

For all the groups, 1% sodium hypochlorite was prepared fresh for each tooth. Final irrigation was with 5 mL distilled water. Subsequently, the samples were returned to dry bottles.

After chemomechanical preparation, the teeth were cleaved and both sections were returned to their original bottles. For each tooth, the most regular hemi-section was chosen for scanning electron microscopy (SEM) analysis (Model XL20 Phillips, Holland). The micrographs (2000×) were numbered and analysed by three experienced professionals on a scoring scale for the apical third of the root canal as per Rome *et al.* (7): a score of 1 indicated an absence of smear layer and dentinal tubules free from debris; a score of 2 indicated moderate presence of smear layer, visible dentinal tubule openings or openings partially obliterated by debris; and a score of 3 indicated abundant smear layer, preventing visualisation of dentinal tubule openings.

Data were analysed using the Kruskal–Wallis test.

Results

A frequency distribution table (Table 1) was created showing the number and percentage of teeth receiving a score in each of the three groups analysed. In Group 1, a thick smear layer was observed in all the samples (Fig. 1). In Groups 2 and 3, the smear layer was almost completely removed (Figs 2,3).

Table 2 shows that there was no statistically significant difference between experimental Groups 2 and 3. Nevertheless, a statistical difference was observed between Groups 1 and 3, and Groups 1 and 2, regarding the pattern of the smear layer present on the root canal wall.

Discussion

In endodontics, little is known about the effects of 24% EDTA gel on the root canal. Thus, the cleaning achieved with 17% EDTA solution and 24% EDTA gel, used during

Table 1 Distribution of smear layer removal scores in three groups submitted to different removal techniques

	Groups							
	NaOCl alone		17% EDTA solution + NaOCl		24% EDTA gel + NaOCl		Total	
Final score	*n*	%	*n*	%	*n*	%	*n*	%
1	0	0.0	2	20.0	3	30.0	5	16.7
2	0	0.0	6	60.0	5	50.0	11	36.7
3	10	100.0	2	20.0	2	20.0	14	46.7
Total	10	100.0	10	100.0	10	100.0	30	100.0

EDTA, ethylenediaminetetraacetic acid.

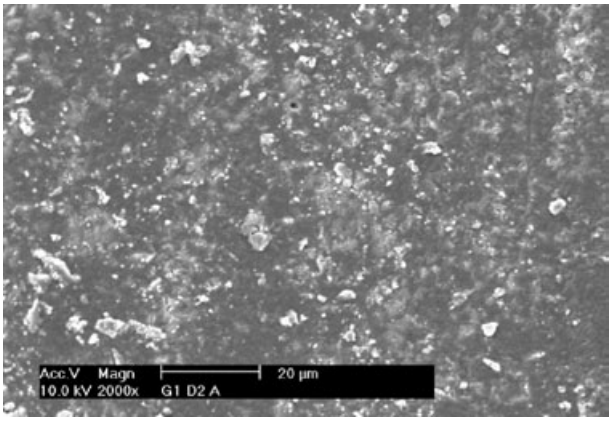

Figure 1 Typical appearance of smear layer.

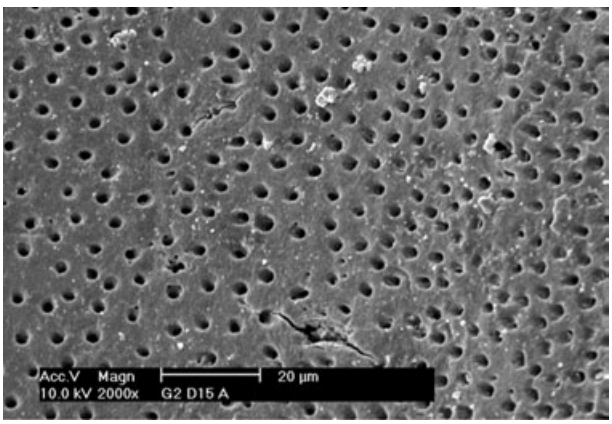

Figure 2 Surface after removal of smear layer with 17% ethylenediaminetetraacetic acid solution.

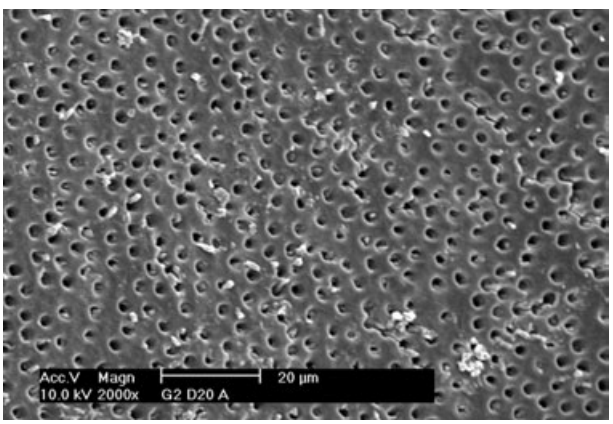

Figure 3 Surface after removal of smear layer with 24% ethylenediaminetetraacetic acid gel.

Table 2 Multiple comparison tests between groups submitted to different smear layer removal techniques

Group	Group mean	Difference	Minimal significant difference	*P*
1 vs. 2	G1 23.5; G2 11.9	11.6	7.72	<0.05
1 vs. 3	G1 23.5; G3 11.1	12.4	7.72	<0.05
2 vs. 3	G2 11.9; G3 11.1	0.8	7.72	>0.05

the chemomechanical preparation of the root canal was comparatively evaluated on 30 human single-root canines examined with SEM. Consistent reports have shown a similar cleaning power for 25% EDTA gel and 17% EDTA solution during canal preparation (8). However, those authors examined middle and apical thirds.

Previous findings (9) show that EDTA alone does not completely remove the smear layer, and that the best results are obtained with EDTA combined with sodium hypochlorite solutions (10,11). In our study, the work of three observers experienced in SEM ensured a reliable evaluation concerning the presence or absence of smear layer. The kappa coefficients for inter-observer agreement were 0.690, 0.839 and 0.639, for the comparison between Observers 1 and 2, 1 and 3, and 2 and 3, respectively. The results were similar and agreement was considered to be good, because none of the coefficients were equal to or lower than the minimum value of 0.5 or equal to, or higher than, the maximum acceptable value of 1.

As shown in Table 1, in Group 1 all the teeth received a score of 3; that is, abundant presence of smear layer and no visible dentinal tubule openings. In Group 2, 20% of the teeth received a score of 1; that is, open dentinal tubules free from smear layer. Sixty per cent of the teeth in this group received a score of 2; that is, moderate smear layer, visible or partially obliterated dentinal tubule openings, and the remaining 20% received a score of 3. The distribution of percentage values for Group 3 was similar to that of Group 2 (30% score 1, 50% score 2 and 20% score 3).

The Kruskal–Wallis test allowed comparison of the cleaning efficacy of these three regimens. The results show a difference between Groups 1 and 2 and also between Groups 1 and 3, but between Groups 2 and 3 there was no statistically significant difference. Based on the present results, it is possible to affirm that in the groups receiving EDTA treatment, the removal of smear layer was more efficient. By contrast, in Group 1, in which only sodium hypochlorite was used, the smear layer was not removed, as previously observed (12,13).

Several studies have demonstrated the capacity of sodium hypochlorite to dilute organic debris (14,15). In this study, the sodium hypochlorite group received scores

that indicated an abundant presence of smear layer on the apical third of the root canal (13). A final irrigation step with 5 mL distilled water may be a useful procedure when using solutions such as EDTA and sodium hypochlorite, known for leaving crystals on the canal walls.

It is likely that the differences observed between Groups 1 (1% sodium hypochlorite) and 2 (1% sodium hypochlorite and 17% EDTA solution) and between Groups 1 and 3 (1% sodium hypochlorite and 24% EDTA gel) are related to the chelating action of EDTA, which also favours the removal of inorganic debris left during the opening of dentinal tubules. This supports the conclusion that the chemical nature of the irrigating solution, and the amount used, definitely influences the cleaning of the root canal (16).

The results found in this study are similar to those reported by Gutierrez *et al.* (2). Those authors concluded that the combined use of EDTA and sodium hypochlorite kept root canals cleaner. We found few published studies comparing EDTA gel and solution, precluding the comparison of the present results with previous reports. Additional research is required to verify the biocompatibility of these mixtures and to confirm their clinical applicability.

Conclusion

None of the substances tested in this study were able to completely remove the smear layer formed during the preparation of root canals on their own. Seventeen per cent EDTA solution and 24% EDTA gel used in association with 1% sodium hypochlorite were more effective in removing the smear layer compared with sodium hypochlorite alone.

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