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Evaluation of the Smear Layer Removal Effectiveness of EDTA Using Two Techniques: An SEM Study

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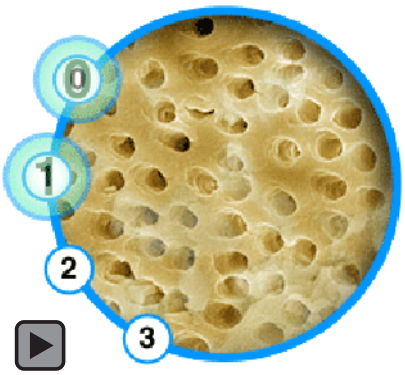

Abstract

Obtaining the cleanest canal possible before obturation is one of the goals of endodontic treatment. The purpose of this study was to compare the smear layer removal capability of ethylenediamine tetra-acetic acid (EDTA) application with passive ultrasonic and cotton wrapped on reamer activation. Twelve extracted human teeth with single root canals were used for the study. They were conventionally hand instrumented using reamers and K files. The apical aspect of the canals was enlarged to a #40 file. The teeth were divided into 4 four groups, instrumented and irrigated as follows: Group-A EDTA agitated at the end of preparation with cotton wrapped on a reamer for 1 min; Group-B EDTA applied with ultrasonic agitation for 1 min; Group-C irrigated with EDTA+sodium hypochlorite (NaOCl) (negative control group); and Group-D irrigated with distilled water (positive control group). After scanning electron microscopic study at three different levels, smear layer and dentinal tubules were scored. Means were tested for significance using the Z test.

When the techniques were compared, the cotton wrapped on reamer agitation method was as successful as the ultrasonic activation of the files. Although all groups had significantly higher smear layer scores at apical compared to coronal sections, no significant differences were recorded.

Keywords: Ultrasonic activation, smear layer, cotton wrapped on reamer, EDTA

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Introduction

Root canal treatment can be summarized as a series of procedures for cleaning, shaping, and filling the root canal system.[1] The problems in cleaning and shaping have resulted in a wide search for innovative materials, instruments, and techniques to obtain a clean disinfected debris-free canal for obturation.[2] The activation of endodontic files by ultrasonic energy has been shown in some studies to be effective in both cleaning and shaping of root canal systems.[3,4,5,6,7] Cunningham et al.[3] showed canals that were cleaned and shaped with ultrasonic instrumentation were significantly cleaner than those instrumented with conventional instrumentation. Tronstad et al.[4] evaluated sonic activation of files to shape and cleanse canals. Their results showed no significant difference between sonically cleaned canals and those cleaned by hand filing with regard to cleanliness. There are some conflicting results for the increased efficacy and advantages of sonic or ultrasonic instrumentation as the primary instrumentation technique.[5,6] When sonic or ultrasonic files are used in curved canals, they may bind restricting their vibratory motion and cleaning efficiency.[7] Using 3 min of sonic or ultrasonic irrigation in each canal of a molar with four canals would add 12 min to the endodontic procedure.

Ethylenediamine tetra-acetic acid (EDTA) is used at neutral pH to promote chelating of calcium in dentin. The smear layer is composed of organic and inorganic components, which can be removed by application of chelating solutions and sodium hypochlorite (NaOCl). Application of EDTA directly onto the dentin is another method for removing the smear layer. EDTA can be applied by cotton wrapped on a file. Using this technique, the smear layer can be removed easily and successfully in a shorter time. In this study we aimed to reduce the time of removing the smear layer. Also, we aimed to evaluate whether 1 min of passive ultrasonic activation would be enough time to effectively remove debris that remained after hand filing.

The purpose of this study was to evaluate smear layer removal efficiency of EDTA used either with ultrasonic agitation or cotton wrapped on a file.

Materials and Methods

Twelve single rooted, straight, extracted maxillary human incisors were used in this study. The specimens were stored in 0.1% thymol solution throughout the experiment. The teeth were divided into two test and two control groups. Test groups included four teeth and control groups included two teeth each. Access preparations were made and patency established by passing a #15 K-file (Antaeos, VDW GmbH, München, Germany) beyond the apex of all canals. Working lengths were determined by subtracting 1 mm from the length at which the file first appeared at the apical foramen. Canals were prepared to #40 K-file 0.5 mm short from the apex with standard preparation technique. One mililiter of 2.65% NaOCl was used between each file size as an irrigant. One operator who was experienced with this method of instrumentation prepared all canals. Then EDTA was applied to the groups as follows:

Group-A EDTA agitated at the end of preparation with cotton wrapped on reamer for 1 min. Canals were dried with paper points after the final rinse and sealed with a cotton pellet and Cavit-G (ESPE, Seefeld, Germany).

Group-B received passive ultrasonic agitation of EDTA for 1 min with a size #15 K-file placed 2 mm short of the working length with EDTA in the canal without touching the walls of the canals.

Group-C served as the negative control group. After the preparation, canals were irrigated with EDTA+NaOCl.

Group-D served as the positive control group. During and after the instrumentation canals were irrigated with distilled water.

After instrumentation, all teeth were dried with paper points (DiaDent, South Korea) and were split along the long axis in the lingo-buccal direction to expose the entire extent of the root canal. One of the halves was then randomly chosen and submitted to scanning electron microscopy (JEOL JSM 6300, Noran Instruments). The length of the root canal was measured and divided equally into cervical, middle, and apical thirds in order to be evaluated

separately. After scanning and observing each region with the microscope, an image of the most representative area of that third was taken with x2000 magnification. Three pictures were obtained from each tooth, one for each third. The images were then analyzed for the amount of smear layer. Qualitative analysis of canal cleanliness was based on the following rating system developed by Rome et al.[8]

0 - no smear layer with opened tubules free of debris
1 - smear layer present only in the apertures of the dentinal tubules
2 - thin smear layer covering the root canal surface and dentinal tubular apertures
3 - heavy smear layer masking dentinal tubular apertures

In order to determine the differences between the groups, statistical analysis was performed using the Z test.

Results

The scores of smear layer remaining in each third are reported in Table 1. When groups were examined separately, Group D (positive control group) exhibited the worst results among the other groups (Figure 1).

Passive EDTA application for 1 min was not satisfactory in Group C (Figure 2).

The smear layer was best removed in Group A (Figures 3 and 4). Group B showed good results in coronal and middle sections.

There were no statistically significant differences among the groups, but the results were unsatisfactory in the apical area (Figure 5). When groups were examined collectively, there were no statistically significant differences among root canal thirds (Z test; $p>0.05$).

Discussion

One of the greatest challenges of root canal treatment is the complete cleaning of the root canal in order to eliminate pulp remnants, bacteria, smear layer, predentin, and other organic material.[2]

NaOCl is the most commonly used irrigant in root canal treatment and has proven to be an excellent irrigating solution due to its capability of dissolving tissue and microbiocidal properties.[2] EDTA compliments the action of NaOCl by chelating calcium ions in dentin and making instrumentation of the canal easier, especially in narrow canals.[1] Because it is a chelating agent, EDTA is not dependent on a high hydrogen ion concentration to accomplish decalcification and is effective at a neutral pH.[9] The efficiency of chelating agents generally depends on many factors, such as the root canal length, penetration depth of the materials, hardness

Table 1. The scores of smear layer remaining in each third.

	Coronal	Middle	Apical
Group A	0	1	2
	0	0	2
	0	1	2
	0	0	0
Group B	0	2	2
	0	0	3
	1	1	3
	0	0	2
Group C	1	2	3
Group D	2	2	3

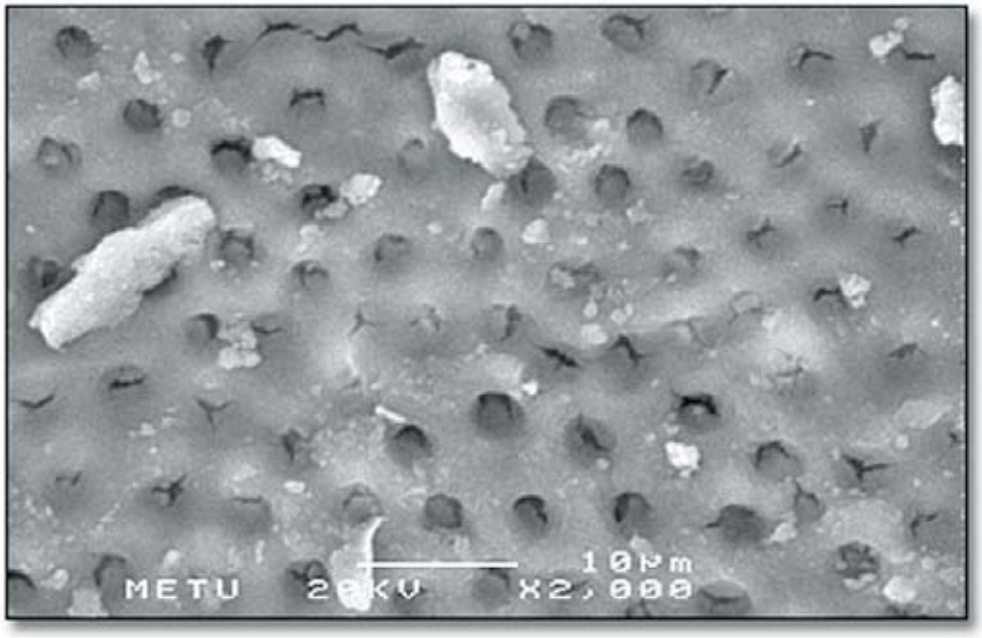

Figure 1. SEM showing the smear layer all over the dentinal tubules (positive control group).

Figure 2. Smear layer couldn't be removed completely (negative control group).

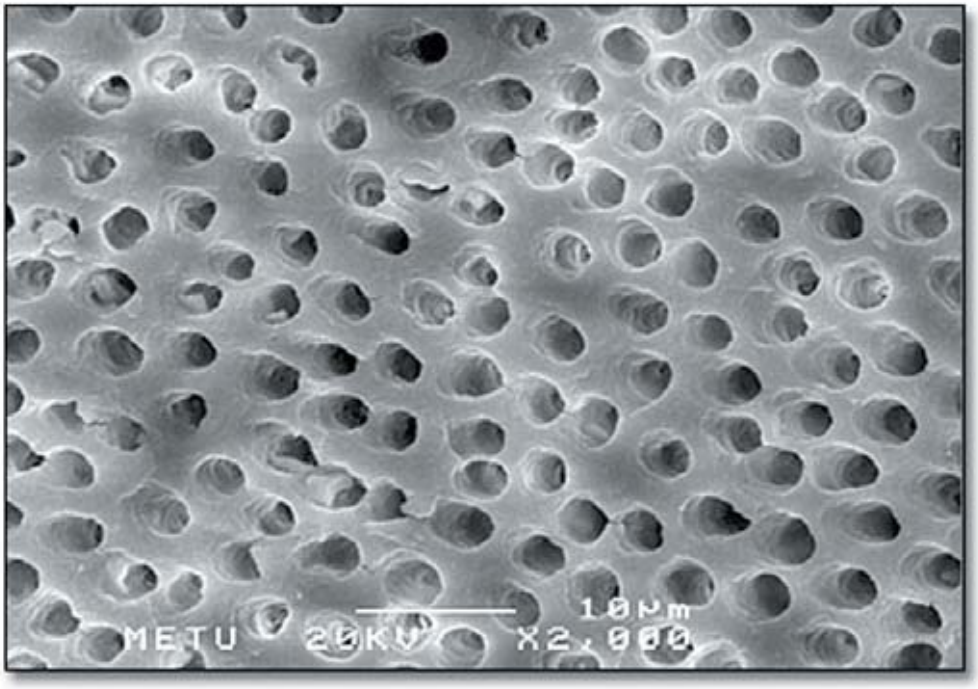

Figure 3. SEM showing the coronal part of Group A.

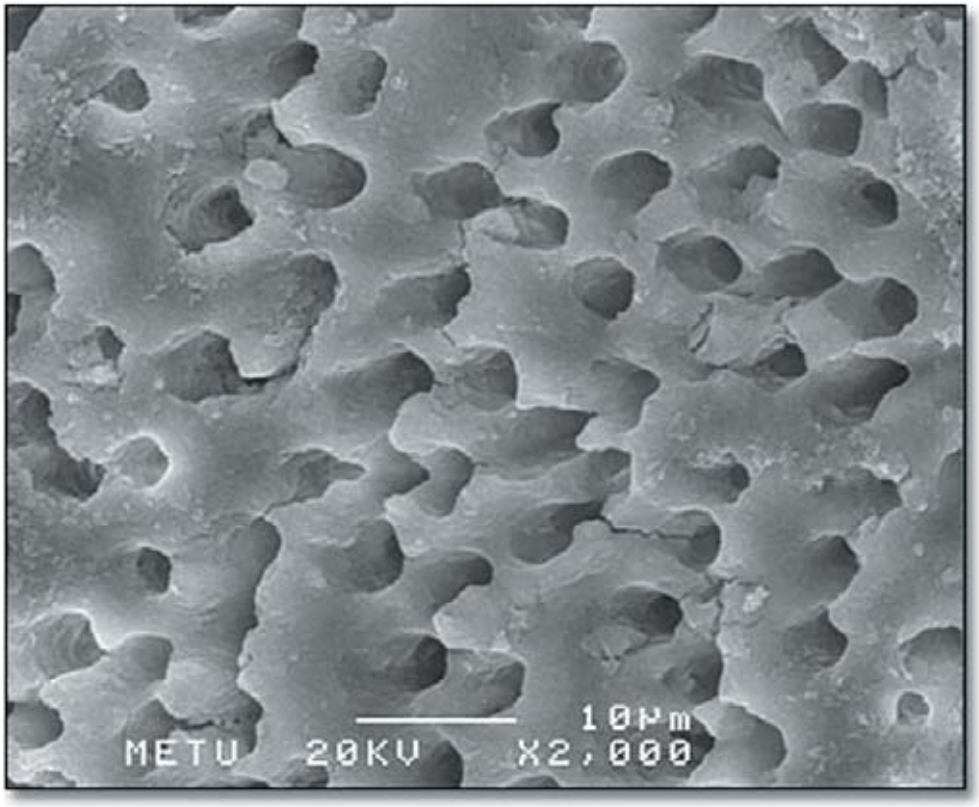

Figure 4. SEM showing the middle part of Group A.

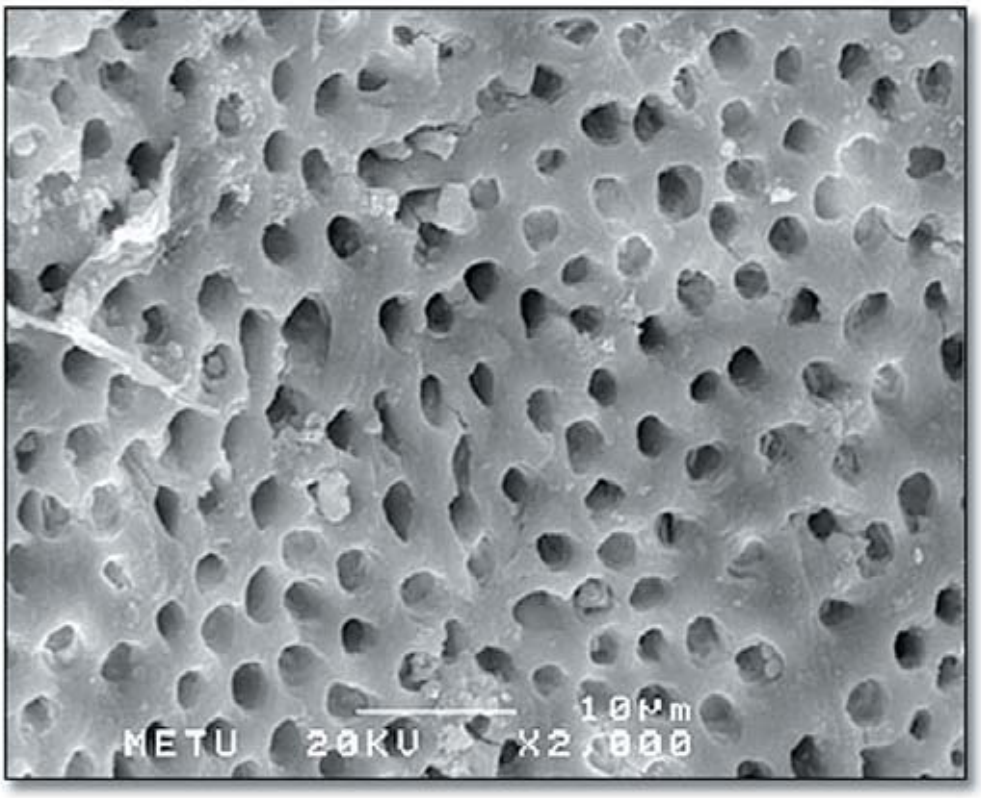

Figure 5. SEM showing the coronal part of Group B.

of the dentin, duration of the application, and concentration.[10,11] The erosive effects of EDTA have also been reported in other studies.[12,13] EDTA effectively does demineralize dentin depending on the concentration and time of exposure. A three minute application of EDTA removes the smear layer but it also causes dentinal tubule erosion.[9] Additionally, this application time is too long in root canal procedures.

These solutions must be in direct contact with the surfaces for effective action. Due to the small diameters of root canals, it is often difficult for the irrigating solutions to reach the apex of the root. Generally irrigants are delivered with a syringe and needle system, but a study showed the apical penetration of the irrigants is only 1 mm beyond the needle tip using radio-opaque irrigant liquids.[14] Ultrasonically activated files may be a means of reaching the entire length of the root canal with irrigating solutions.[15] To improve surface contact, EDTA solution was activated either with ultrasonic agitation or applied with cotton wrapped on reamer in this study. Cotton wrapped on reamer might remove the smear layer easily and in a shorter time period without erosion of dentin surfaces.

In this study it was presumed direct application of EDTA with shorter time periods to the canal walls and the agitation caused by the file activated by ultrasound cleaned the root canal walls in their entire length. In this experiment, ultrasound did not remove the smear layer better than cotton wrapped on reamer. In the current study an irrigation time of 1 min for EDTA and NaOCl was selected after canal preparation, as this seems clinically practical. The clinical relevance of this study indicated activated irrigation did not significantly reduce the smear layer when using ultrasonic energy, especially in the apical section. In the coronal and middle parts, both ultrasonic activation and cotton wrapped on reamer yielded favorable results. Furthermore, the cotton wrapped on a reamer technique did not cause erosion on root canal walls. This result can be perceived as an advantage.

Although differences were found regarding treatments, no statistical differences were found in the apical third of the roots. There are several reports confirming a greater amount of smear layer can be found at the apical level of root canals treated with NaOCl and EDTA.[16,17,18,19]

Conclusion

Within the limits of this study, using a small sample size, the following conclusions can be made:

- In order to reduce the erosive effects of EDTA solutions during prolonged cleaning and shaping of root canals, a shorter application time of EDTA should be utilized with agitation.[20]
- Application of EDTA using a cotton wrapped on reamer can reduce the dentinal erosion and time of exposure.

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