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A Scanning Electron Microscopy Analysis of the Impact of EDTA and Citric Acid on the Removal of Smear Layers in the Mesial Canals of First Mandibular Molars

Mukta Bansal , Dr. Prateek Singh , Asheesh Sawhny , Pankaj Priyadarshi , Anu Singh , Richa Singh , Prateek Singh

Rama Dental College Hospital and Research Centre, Rama University, Mandhana, Kanpur, Uttar Pradesh, India

drasheeshk.rdc@ramauniversity.ac.in

Abstract

Background: This in vitro investigation set out to ascertain how EDTA and citric acid affected the clearance of smear layers in various root canal locations.

Materials and Method: 48 recently removed adult human mandibular first molar teeth with mesial roots that were 20–23 mm long and bent between 15 and 45 degrees were utilized in this investigation. The crown down method of instrumentation was carried out by hand and rotary filing. NaOCl was the irrigant utilized in the instrumentation. Three groups of teeth were identified. Group I received an irrigation of 17% EDTA, Group II received a treatment of 7% citric acid, and Group III received a treatment of 5.25% NaOCl as a control. Following that, the mesial roots were divided in half and examined using scanning electron microscopy.

Results: According to 17% EDTA and 7% citric acid, the levels of cleanliness were 96.55% and 95%, respectively. While both solutions were suitable, EDTA outperformed citric acid, particularly in the middle and apical thirds of the canals, and the difference between them was statistically significant ($P<0.05$). The middle third of the apical region had the greatest reduction of the smear layer, with less removal occurring there than elsewhere. On the other hand, both groups found it appropriate to remove the smear layer in the apical region.

Conclusion: It appears that using 7% citric acid and 17% EDTA together can provide the intended effects and eliminate the smear layer from curved and narrow canals, particularly in the apical area.

Keywords: EDTA, citric acid, smear layer, irrigation

INTRODUCTION

A thorough root canal system debridement is necessary for an endodontic procedure to be successful[1]. The treated tooth should be prepared for the filling material that will close the apical foramen in addition to having the pulp tissue, necrotic debris, bacteria, and damaged dentin removed. But if dentin is removed, a thin smear layer that covers the whole root canal wall will always form[2, 3]. This layer was initially shown in instrumented root canals by McComb and Smith[4].

Both organic and inorganic elements, such as microbes, necrotic materials, and pieces of odontoblastic processes, are present in the smear layer[5, 6.]

This smear layer stops intracanal medicine from penetrating into the dentinal tubule and root canal system abnormalities. It also stops obturating materials from fully adapting to the prepared root canal surface[7].

Orstavik and Haapasalo demonstrated the significance of smear layer removal and patent dental tubules in an in vitro investigation, which reduced the amount of time required to accomplish the disinfecting action of intracanal medicines. Additionally, Bystrom and Sundqvist demonstrated that the existence of a smear layer can prevent or greatly slow the entry of antimicrobial agents into the dentinal tubules, including intracanal irrigants and medications[8, 9.]

While the impact of eliminating the smear layer on the outcome of a root canal procedure remains debatable, removing it appears to be preferable to leaving it in place[7].

In order to remove the inorganic component of the smear layer, an organic solvent called NaOCL must be used with acids like phosphoric, citric, tannic, or polyacrilic acid, or chelating agents like EDTA orEDTA.

According to Goldman et al. (2011) and Yamada et al. (2012), the smear layer can be successfully removed by using a large final flush with 17% EDTA and sodium hypochlorite (NaOCL) thereafter. Tetracycline Hcl has also been suggested as a means of eliminating the smear layer from instrumented canal and root end cavity preparation surfaces, in addition to acids[13, 14].

Several investigations have demonstrated the ability of EDTA and citric acid to dissolve the smear layer, opening the dentinal tubules and improving the penetration of medications and filling material. Nevertheless, there aren't many research that compare these two dissimilar materials. This study compared the efficacy of these two irrigants in removing smear layers from the mesial canals of first mandibular molar teeth, which are the hardest canals for irrigants to penetrate, particularly in the apical areas.In order to conduct this investigation under clinical settings, the crowns were not cut.

MATERIALS & METHOD

The study utilized 48 newly removed mature human mandibular first molar teeth that still had their crowns intact. According to Schneider categorization, their mesial roots had a curvature of 15–45 degrees, and their lengths ranged from 20–23 mm.[15]

A k-type file (size 08 or 10) was used to measure the working length of each canal after a traditional access preparation was completed. The file was inserted into the apical foramen and pulled back into the clinically visible foramen. Mesial canals have a working length of 20 to 23 mm. In order to instrument the mesial canals, the following steps were taken: first, the cervical region was flared using a gates glidden drill (Mani Japan) number 2, 3, and 4 using the crown down technique; next, the profile was filed and flared using a rotary system (Dentsply Maillefer, Ballaigues, Switzerland)[16]. The procedure was carried out in this order:

20 (04), 20 (06), 25 (04), 25 (06), 30 (06)

Patency files and 1 milliliter of 5.25% NaOCl were employed as an irrigant in between each instrument. Every canal's apical foramen was extended to a diameter of 30 (06) rotary profiles. Following instrumentation, the teeth were separated into three groups, and a 27-gauge needle syringe was used for the last irrigation. These groups include:

Group 1: 22 teeth: 5 ml of 17% EDTA that had been buffered with PH=7.8 for 5 minutes was used as the first irrigation, followed by 5 ml of 5.25% NaOCl and 5 ml of distilled water.

Group 2: 22 teeth: 5 ml of 7% citric acid was irrigated for 5 minutes, followed by 5 ml of 5.25% NaOCl and 5 ml of distilled water.

Group 3 (control): 4 teeth. In this group, 5 ml of 5.25% NaOCl and 5 ml of distilled water were used to irrigate the canals.

To end the irrigation process and avoid any sedimentation, such as the formation of citrate crystals, a final irrigation using distilled water was carried out.

In order to prevent dentinal shards from entering the canals during root splitting, a little piece of cotton was initially placed into the mesial orifices during irrigation. The mesial roots were divided longitudinally in the buccolingual direction. Half of each root was then disposed of and the other half was soaked in a 2% glutaraldehyde solution for a whole day.

The preserved specimens were dehydrated using increasing concentrations of ethyl alcohol (30% – 100%), washed three times with a sodium cacodylate buffered solution (0.1 M, PH 7.2), and then incubated in osmium tetroxide for an hour. Finally, they were kept in a desiccator for a minimum of twenty-four hours.

Each specimen was studied under a scanning electron microscope after being placed on an aluminum stub and coated with 25 µm of gold palladium.

All of the photomicrographs had the same surface unit and a × 2500 magnification.

The final irrigation solution was used to code the specimens. Two investigators used blind criteria to rate the cleanliness percentage at the coronal, middle, and apical section of each canal as well as the presence or absence of a smear layer in the dentinal tubules or on the surface of the root canal:

1. The total number of tubules – the total number of closed tubules equals the number of opened tubules.
2. The percentage of cleanliness is equal to (the total number of tubules / the number of opened tubules) x 100. Student t, ANOVA, and Duncan tests were used in the statistical analysis of the data.

RESULTS

Table 1 summarizes the study's findings, while images 1 through 9 display scanning electron photomicrographs of the control and irrigated samples using 17% EDTA, 7% citric acid, and 5.25% NaOCL.

This study found that 17% EDTA eliminated the smear layer more well than 7% citric acid. In the middle and apical areas, EDTA was shown to be superior to citric acid; however, there were no notable differences between the two solutions in the cervical region. Additionally, it was observed that the apical third had the lowest level of cleanliness and the middle third had the best.

DISCUSSION

In this investigation, 17% EDTA produced a cleaner sample than 7% citric acid. From a therapeutic perspective, both of these materials appear to be appropriate, despite the statistically substantial difference between them. The findings of this study bear some resemblance to those of other research studies [12, 17, 18]. According to Yamada et al. [12] 17% EDTA is more efficient than 25% citric acid. The samples in this investigation, which was conducted on single-rooted teeth, were only subjectively assessed; no statistical comparison or amount evaluation was employed. Conversely, for canal preparation, gates glidden drilling and manual instrumentation were employed.

There were no changes found by Takeda et al. [18] between 17% EDTA and 6% citric acid. Their study similarly employed hand instruments for canal preparation, and photomicrographs were graded on a four-point scale (0–3).There were no changes found between 10% citric acid and EDTA-T, a mixture of 17% EDTA and tergentol, according to Scelza et al. [17]. Straight single-rooted teeth were used in the study, and manual instrumentation was the sole method

used to prepare the canals. A comparison was conducted by Lenarda et al. [19] between 15% EDTA and 1 mol/L citric acid. A rotating profile system was used to prepare certain samples, while manual instrumentation was used for others. They felt that EDTA was more effective in samples generated by manual instrumentation, and that citric acid was more effective than EDTA, particularly in samples prepared using a profile rotary system. Their research shown that the instrumentation method might alter the smear layer removal capacity when using various solutions.In our investigation, there were no discernible differences between 17% EDTA and 7% citric acid in the cervical area regarding the degree of smear layer removal in the various canal locations. In the intermediate and apical areas, 17% EDTA is preferable to 7% citric acid.

While 7% citric acid cleaned the cervical and middle areas better than the apical region, it was found that 17% EDTA cleaned the middle region more thoroughly than other canal regions.The least clean area in our investigation was the apical region. Our findings also conflict with Scelza's study[17], which discovered that the middle and apical areas are identical. Yamada et al.'s results, which identified the apical region as the cleanest zone, are entirely different from ours. The similar finding was also made by Takada et al. (2018).

Given that the apical area is both the most crucial and challenging to remove from smear layers, the level of cleaning attained with both solutions—95.9% EDTA and 92.5% citric acid—was rather good. This demonstrates that the study's final irrigation and canal preparation techniques were successful in removing the smear layer. We could achieve more cleanliness in this area if we could enhance irrigation penetration into the apical region. For instance, using detergents to lower surface tension, a miniature brush, or a thinner needle might produce far superior results.

Based on the study's findings, smear layer removal may be successfully accomplished using either EDTA or citric acid. We recommend that further clinical trials in this area be organized in the future.

Region	Scanned Region	17% EDTA	7% Citric Acid	P Value
Cervical	88	95.87 ± 7.00	95.44 ± 3.57	0.657
Middle	88	97.9 ± 2.36	96.03 ± 4.69	0.031
Apical	88	95.87 ± 4.52	92.52± 6.11	0.008
Total	264	96.55 ± 5.05	95 ± 5.17	0.023

Table 1. The amount of smear layer removal (on percentage) in two groups: 17% EDTA and 7% citric acid. Data are mean ± SD.

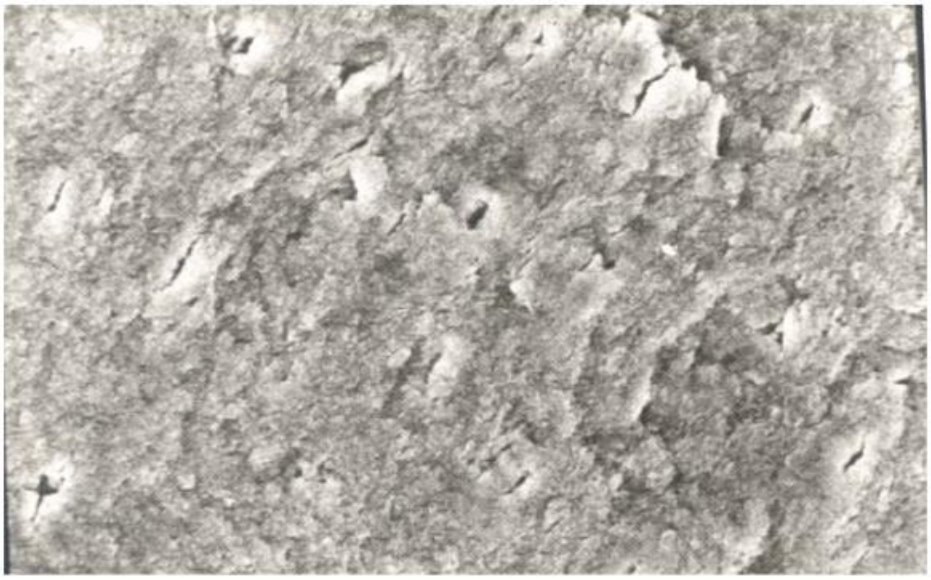

Figure 1. Photomicrograph of cervical region of canal irrigated with 5.25% NaOCl (control sample) showing the presence of the smear layer.

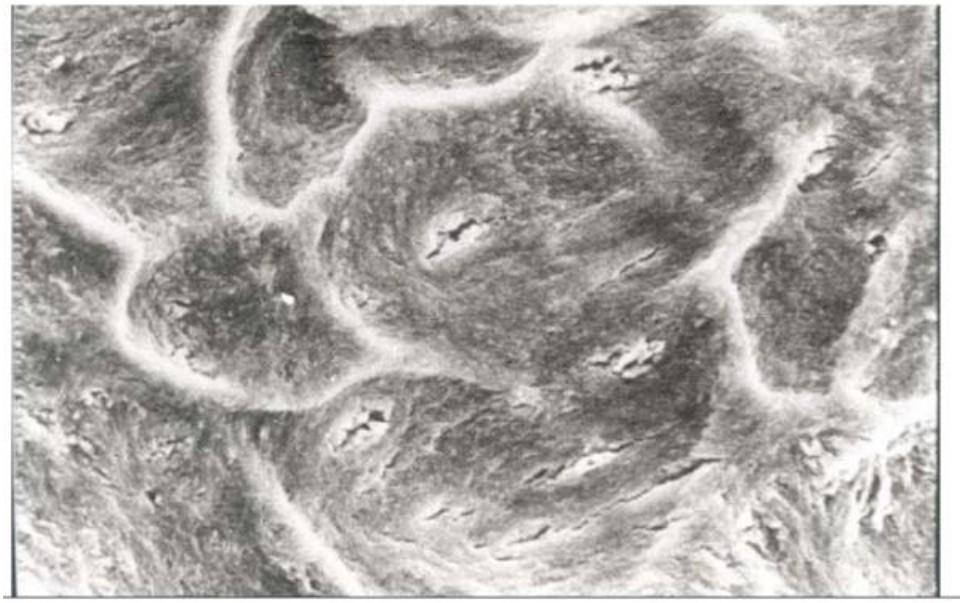

Figure 2. Photomicrograph of middle region of canal irrigated with 5.25% NaOCl (control sample) showing the presence of the smear layer.

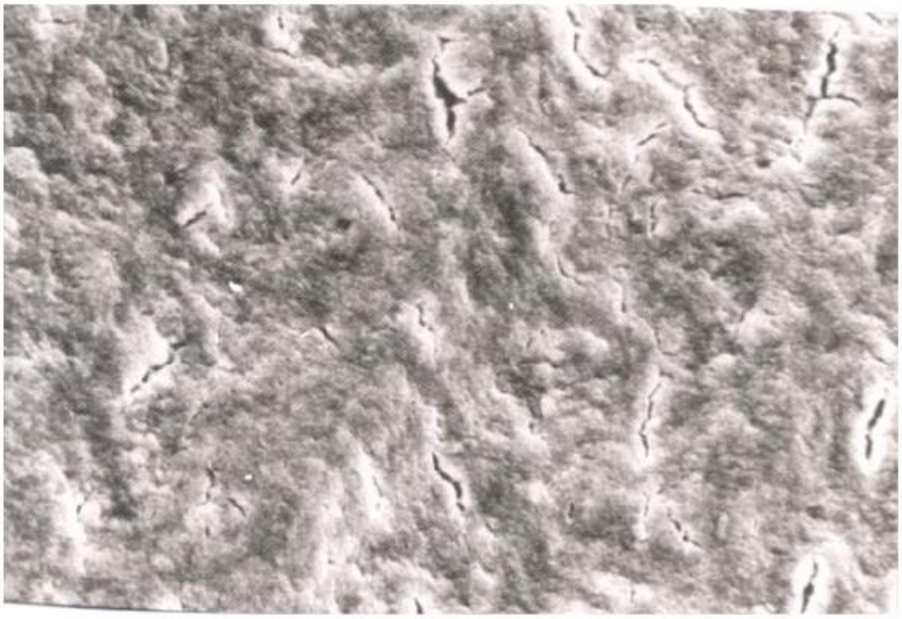

Figure 3. Photomicrograph of apical region of canal irrigated with 5.25% NaOCl (control sample) showing the presence of the smear layer.

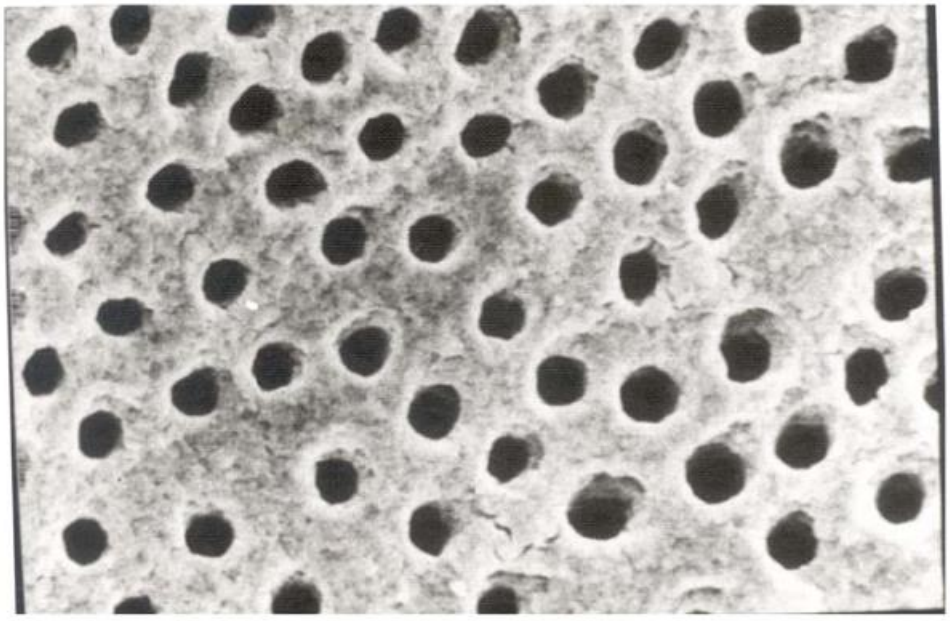

Figure 4. Photomicrograph of cervical region of canal irrigated with 17% EDTA + 5.25% NaOCl showing the removal of the smear layer and open dentinal tubule.

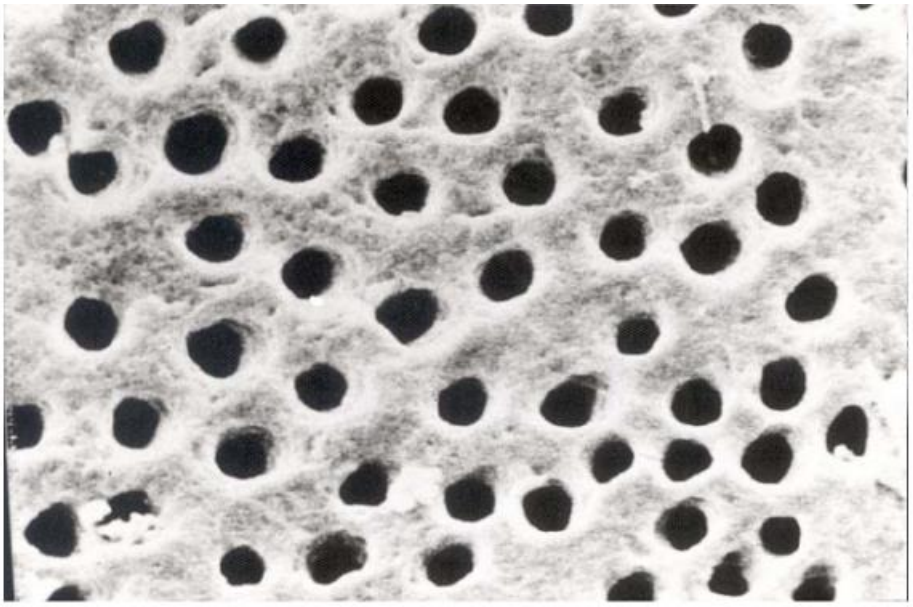

Figure 5. Photomicrograph of middle region of canal irrigated with 17% EDTA + 5.25% NaOCl showing the removal of the smear layer and open dentinal tubule.

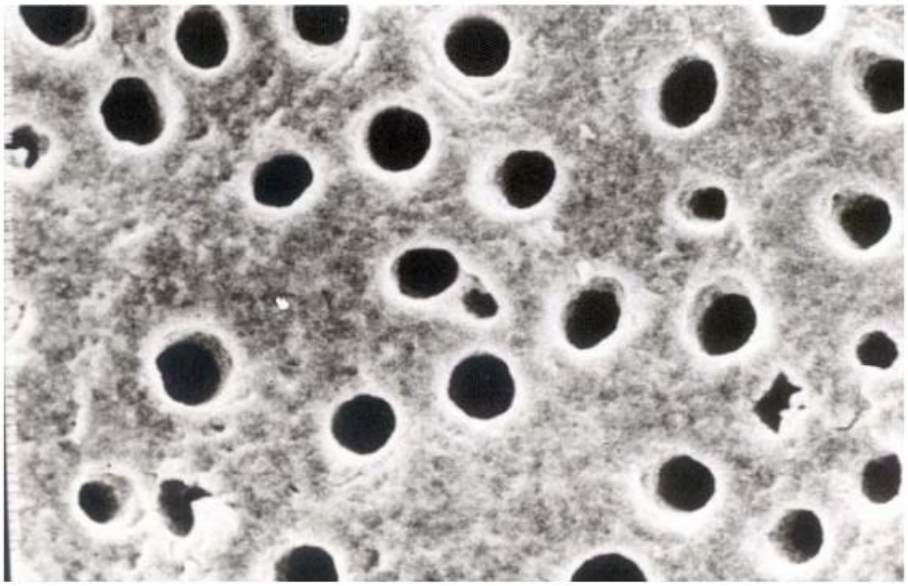

Figure 6. Photomicrograph of apical region of canal irrigated with 17% EDTA + 5.25% NaOCl showing the removal of the smear layer and open dentinal tubule.

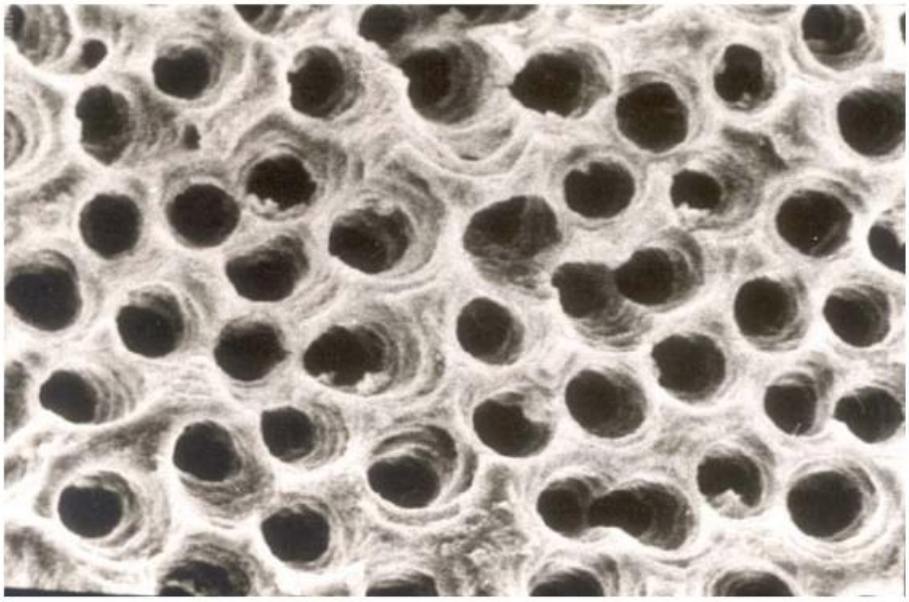

Figure 7. Photomicrograph of cervical region of canal irrigated with 7% citric acid + 5.25% NaOCl showing the removal of the smear layer and open dentinal tubule.

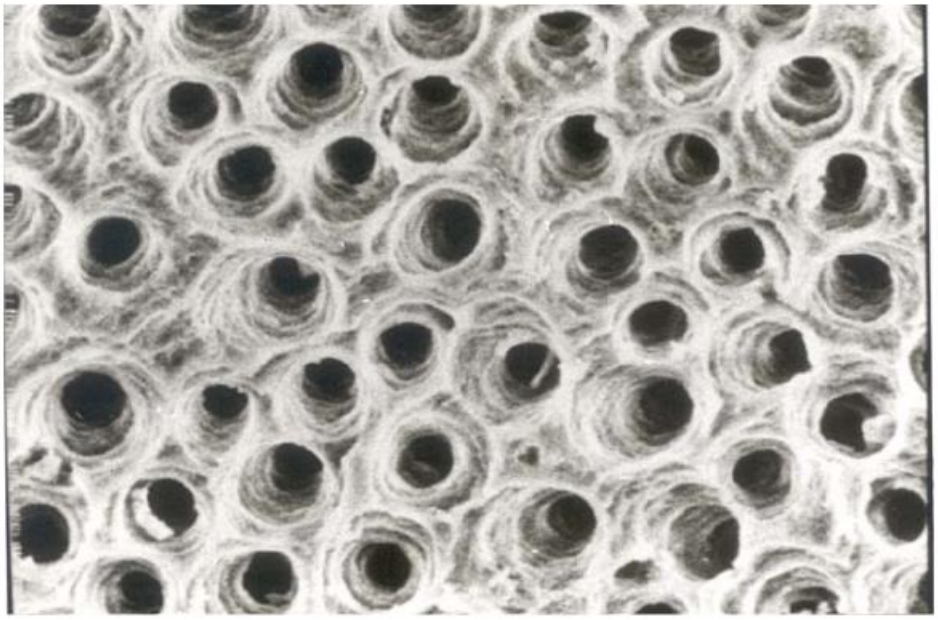

Figure 8. Photomicrograph of middle region of canal irrigated with 7% citric acid + 5.25% NaOCl showing theremoval of the smear layer and open dentinal tubule.

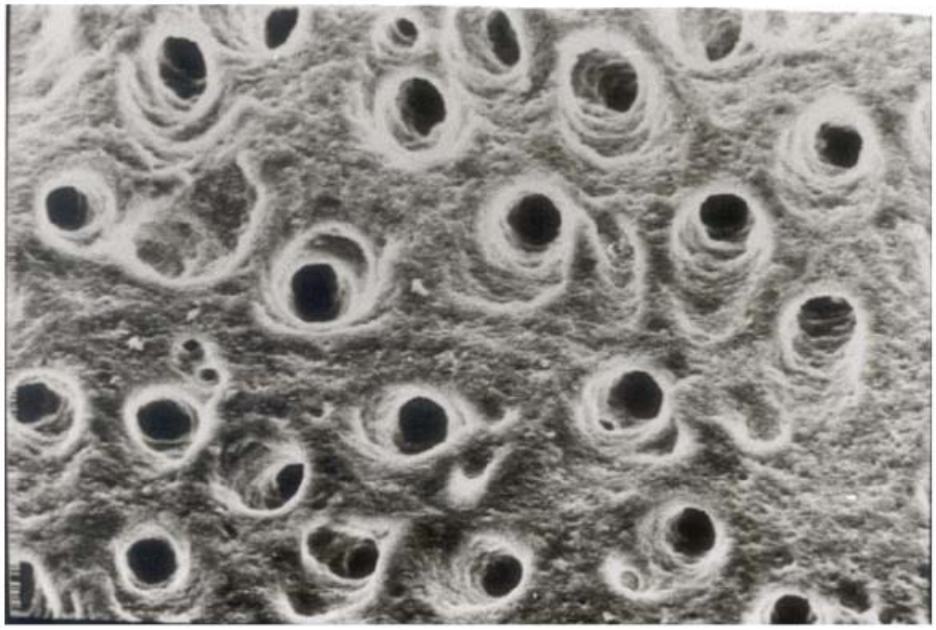

Figure 9. Photomicrograph of apical region of canal irrigated with 7% citric acid + 5.25% NaOCl showing theremoval of the smear layer and open dentinal tubule.

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AUTHORS:

Name: Mukta Bansal
Designation/ College Name: Senior Lecturer, Department of Conservative Dentistry and Endodontics, Rama Dental College Kanpur UP India
Mail Id: drmuktabansal92@gmail.com
Mobile Number: +91- 9736653155

Name: Asheesh Sawhny
Designation/ College Name: Professor and Head of Department, Department of Conservative Dentistry and Endodontics, Rama Dental College Kanpur UP India
Mail Id: drasheeshmydentist@yahoo.com
Mobile Number: +91- 9838500100

Name: Pankaj Priyadarshi
Designation/ College Name: Senior Lecturer, Department of Conservative Dentistry and Endodontics, Rama Dental College Kanpur UP India
Mail Id: Pankaj.priyadarshi24@gmail.com
Mobile Number: +91- 7007641869

Name: Anu singh
Designation/ College Name: Reader, Department of Conservative Dentistry and Endodontics, Rama Dental College Kanpur UP India
Mail Id: anusingh144@gmail.com
Mobile Number: +91- 8400836432

Name: Richa Singh
Designation/ College Name: Senior Lecturer, Department of Conservative Dentistry and Endodontics, Rama Dental College Kanpur UP India
Mail Id: richasingh2804@gmail.com
Mobile Number: +91- 9838870041

Name: Prateek singh
Designation/ College Name: Senior lecturer, Department of Conservative Dentistry and Endodontics, Rama Dental College Kanpur UP India
Mail Id: kushwahprateek@gmail.com
Mobile Number: +91- 956049069

CORRESPONDING AUTHOR:

Name: Mukta Bansal
Designation/ College Name: Senior Lecturer, Department of Conservative Dentistry and Endodontics, Rama Dental College Kanpur UP India
Mail Id: drmuktabansal92@gmail.com
Mobile Number: +91- 9736653155